CASIO

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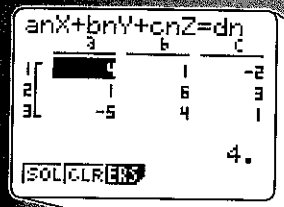
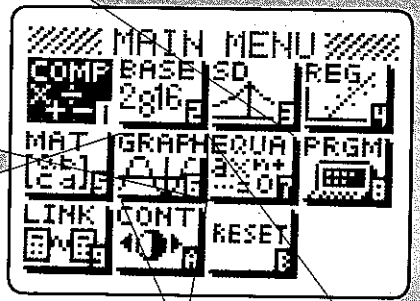
31C ㊊ Printed in Hong Kong

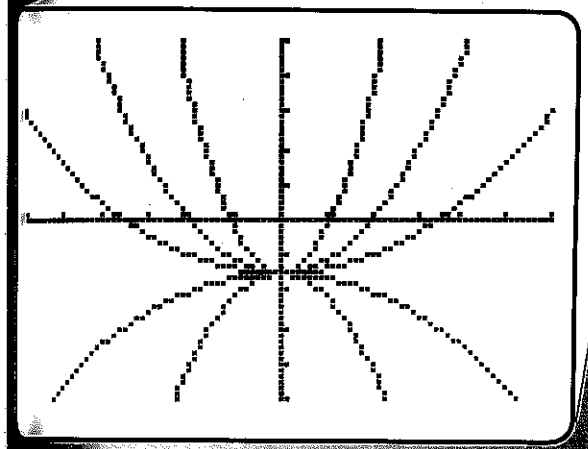
U.S. Pat. 4,410,955

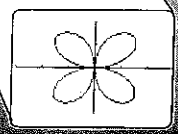
fx-7700GE **Owner's manual** CASIO

POWER GRAPHIC
fx-7700GE
Owner's manual









CASIO

NOTICE

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC WARNING

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Proper connectors must be used for connection to host computer and/or peripherals in order to meet FCC emission limits.

Connector SB-62	Power Graphic Unit to Power Graphic Unit
Connector FA-121 Ver 2.0	Power Graphic Unit to PC for IBM/Macintosh Machine

IBM is a registered trademark of International Business Machines Corporation.
Macintosh is a registered trademark of Apple Computer, Inc.

Quick-Start

Welcome to the world of Graphing Calculators and the CASIO fx-7700GE.

Quick-Start is not a complete tutorial, but it will take you through many of the most common functions, from turning the power on through graphing complex equations. When you're done, you'll have mastered the basic operation of the fx-7700GE and will be ready to proceed with the rest of this manual to learn the entire spectrum of functions the fx-7700GE can perform.

Each step of every example is shown graphically to help you follow along quickly and easily. For example, when you need to enter the number 57, we've indicated it as follows:

Press [5] [7]

Whenever necessary, we've included samples of what your screen should look like. If you find that your screen doesn't match the sample, or in fact you need to start over for any reason, you can do so by pressing the "All Clear" button. [AC/ON]

POWER ON/OFF

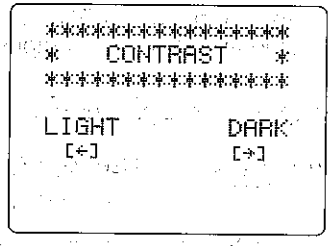
To turn your unit on, press [AC/ON]

To turn your unit off, press [SHIFT] [OFF AC/ON]

NOTE: *Your unit will automatically shut itself off after six minutes of inactivity.*

ADJUSTING THE CONTRAST

1. Press [MENU]
2. Use ◀ ▶ ▲ ▼ to select the CONT icon, and press [EXE]. The following screen will appear:



3. Press ◀ to lighten screen or ▶ to darken screen.
4. Press [MENU] to clear the screen.

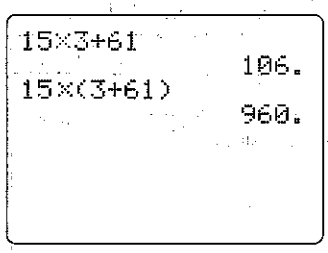
Grouping within an equation

You can also group certain operations within your equation using the parentheses keys. [( ] [ )]

EXAMPLE: 15 x (3 + 61)

1. Press [1] [5] [×] [(] [3] [+] [6] [1] [)] [EXE]

The following screen will appear:



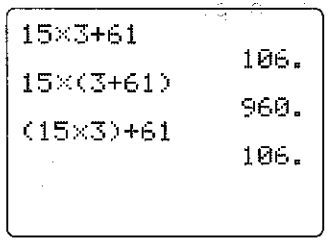
Note that your previous calculation remains on the screen. The new calculation is displayed beneath it for easy comparison.

Now let's try a variation on that problem by positioning the parentheses differently.

EXAMPLE: (15 x 3) + 61

1. Press [(] [1] [5] [×] [3] [)] [+] [6] [1] [EXE]

The following screen will appear:



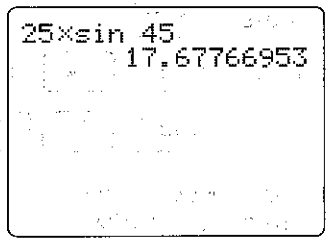
As you can see, the fx-7700GE displays all three problems simultaneously.

USING BUILT-IN VALUES

The fx-7700GE features several convenient built-in functions and values that you can enter into your equations quickly and easily.

EXAMPLE: 25 x sine of 45 (In Deg mode)

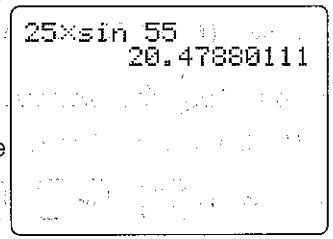
1. Press [AC/ON]
2. Press [2] [5] [×] [sin] [4] [5]
3. Press [EXE] and the answer will appear on the screen as follows:



Using the Replay feature

With the replay feature, you can go back in and change any part of your equation at any time, even after the fx-7700GE computes the answer, without having to rewrite the entire equation. We'll use the previous equation as an example. Let's say you need to change the sine of 45 to sine of 55, but everything else in the equation remains the same.

1. Press [◀] This will bring you back into the equation.
2. Press [◀] twice so the flashing cursor is on the 4.
3. Press [5] to overwrite a 5.
4. Press [EXE] and the fx-7700GE will quickly recompute the new solution:



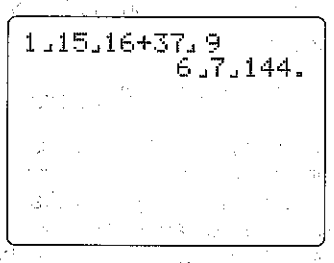
FRACTIONS

The fx-7700GE makes it easy to work with fractions with its fraction key. [a b/c] On screen, the ⌟ symbol is entered between each value of the fraction. For example, $1\frac{15}{16}$ would appear as 1⌟15⌟16

EXAMPLE: $1\frac{15}{16} + \frac{37}{9}$

1. Press [AC/ON]
2. Press [1] [a b/c] [1] [5] [a b/c] [1] [6]
   [+] [3] [7] [a b/c] [9] [EXE]

The answer will appear on the screen as follows:



Converting the answer to a decimal equivalent

With the answer still on your screen,

1. Press [EXE] [a b/c] and the decimal equivalent of your answer (6.048611111) will appear on the screen.

Converting the answer to an improper fraction

With the answer still on your screen,

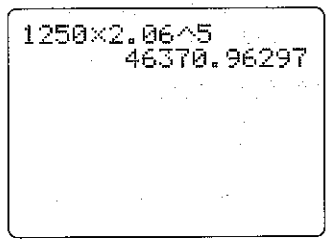
1. Press [EXE] [SHIFT] [a b/c] and your answer (871⌟144) will appear on the screen in the form of an improper fraction.

EXPONENTIALS

Exponentials are another function the fx-7700GE can perform quickly and easily.

EXAMPLE: 1250×2.06^5

1. Press [AC/ON]
2. Press [1] [2] [5] [0]
   [×] [2] [.] [0] [6]
3. Now you are ready to enter the exponent value. Press the exponent key [^] and ^ will appear on the screen. The number directly preceding the ^, in this case 2.06, is the base number.
4. Press [5] The number 5 now appears after the ^ symbol, and represents the exponential value.
5. Press [EXE] and the answer will appear on the screen as follows:



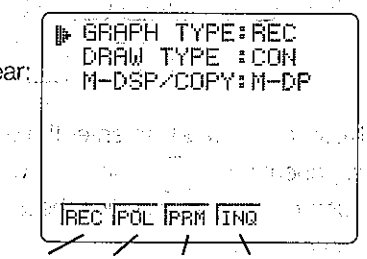
GRAPHING

The fx-7700GE has the ability to present graphic solutions to a variety of complex equations. Before drawing a graph, be sure to first specify the graph type.

Specifying the graph type

1. Select the COMP (computation) mode.
2. Press [SHIFT] [MENU] (SET UP).

   The following screen will appear:



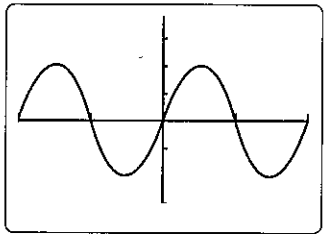
3. Press [F1] to specify the REC mode for drawing of a rectangular coordinate graph.
4. Press [EXIT] to return to the previous screen.

Graphing a built-in function

The fx-7700GE can quickly create a graph of one of its built-in values or functions.

EXAMPLE: y = sin x

5. Press [Graph]
6. Press [sin] (x is assumed)
7. Press [EXE] and the following graph will appear:



Returning to the equation

If you find that you need to return to your equation to change or replace certain values, you can do so simply by pressing the Graph-Text toggle key. [G↔T]

The fx-7700GE has two separate areas of its memory: one for your formula, the other for graphs.

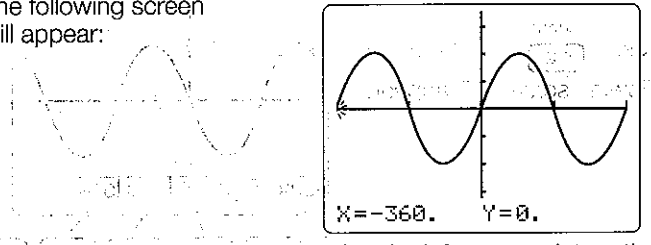
1. Press [G↔T] once to see the equation, then again to see the graph.

Trace function

The trace function lets you select an exact point on the graph and display the coordinates of that point.

1. With the graph still on your screen, press [F1] (Trace)

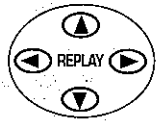
   The following screen will appear:



Notice that a cursor has appeared at the left-most point on the X axis and its coordinates have appeared at the bottom of the screen. Move the cursor to the right by pressing the ▶ key, then back to the left using the ◀ key. Pressing the button once will move the cursor one point, while holding it down will cause continuous movement. (The values may be approximated due to the space limitations of the screen.)

2. Press [F6] (Coord) to view the full value of the X coordinate in unabbreviated form.
3. Press [F6] (Coord) to view the full value of the Y coordinate in unabbreviated form.
4. Press [F6] (Coord) a third time to see both coordinates simultaneously.
5. Press [F1] (Trace) to exit the trace function.

Scrolling in four directions



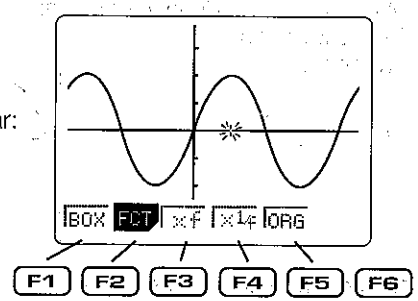
1. Pressing any arrow key lets you scroll to see different sections of your graph.

Returning to your original graph

After scrolling, you needn't retrace your steps to get back to your original graph. You can do it quickly and easily using the function keys (F keys) to enter a selection from one of the many FUNCTION MENUS the fx-7700GE employs. A function menu is a group of up to 6 functions that are displayed across the bottom of the screen. To select one of the choices, press the corresponding F key.

2. Using the ▶ key, scroll so the Y axis is at the left of the screen.

3. Press Zoom [F2] and the following screen will appear:



The first five function keys in the function menu each correspond to one of the five boxes along the bottom of the screen. (The sixth function key is inactive in this instance.) The one we'll concern ourselves with now is [F5] which corresponds to ORG (original) on the screen.

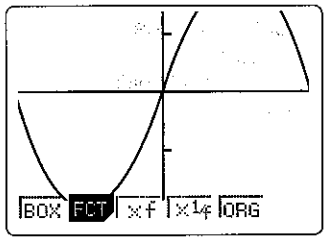
4. Press [F5] to bring you back to your original graph.

Zoom function

Another of the powerful graphing features of the fx-7700GE is zooming. This allows you to enlarge a portion of your graph for detailed analysis, or zoom out for a broader view.

Zooming in

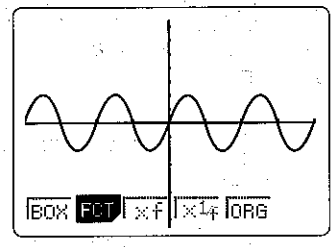
1. Press [F3] which corresponds to the ×f box on the screen, to zoom in on your graph. The screen will now show a view that is enlarged by a predetermined factor. (Later in the manual, you'll learn how to set your own factor of enlargement or reduction.)



2. Press [F5] to return to your original graph.

Zooming out

3. Press [F4] which corresponds to ×1/f on the screen, to zoom away from the graph. The screen should now look like this:

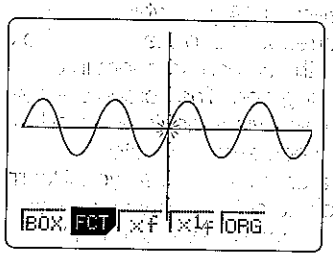


Using the Box function to zoom

This function lets you define any portion of the screen and magnify it for further analysis.

1. Press [F2] to display the zoom function menu.
2. Press [F1] which corresponds to BOX on the screen.

The following screen will appear:
Notice that the blinking cursor is at the origin.



3. Using the arrow keys, move the cursor to a spot which will define one corner of the area, or "box," you wish to zoom in on.

4. Press [EXE] to "anchor" the cursor, creating the first corner of the box. Now, use the arrow keys to draw a box over the area you wish to enlarge.
5. Press [EXE] and the area you defined will enlarge to fill the entire screen.
6. Press [F2] to display the zoom function menu.
7. Press [EXIT] twice to clear the zoom function menu.

INTEGRATION GRAPH

Setting the mode

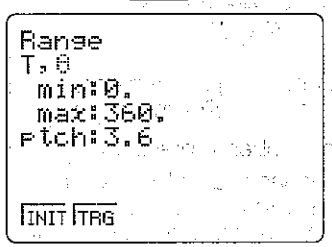
1. Press [SHIFT] [MENU (SET UP)] [F1] to specify the REC mode for drawing of a rectangular coordinate graph, and then press [EXIT].

Setting the range

Before graphing an integral, you need to define the range of each axis by setting its maximum and minimum value. You also need to set the scale by which each axis will be divided. This is done as follows:

2. Press [AC/ON] 3. Press [Range] to display the range input screen.
4. Set the Xmin range to -5 by pressing [(−)] [5]
   Press [EXE] and -5 will overwrite the existing value and move the cursor to the next value.
5. Set the X max range to 10 by pressing [1] [0] [EXE]
6. Set the X scl (scale) to 5 by pressing [5] [EXE]
7. Set the Y min range to -8 by pressing [(−)] [8] [EXE]
8. Set the Y max range to 8 by pressing [8] [EXE]
9. Set the Y scl (scale) to 5 by pressing [5] [EXE]

The following screen will appear:
This second range screen is sometimes needed to set additional values. However, since none are necessary for this example, press [Range] to bypass the screen.



Creating the graph

An integration graph is just one of many types of graphs the fx-7700GE can generate in just a few keystrokes.

EXAMPLE: $\int_1^5 (x - 1)(x - 5)\,dx$

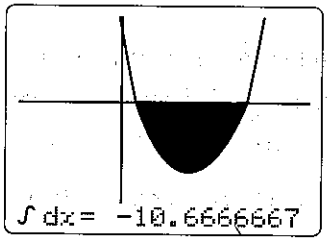
10. Press [SHIFT] [G↔T] (G-∫dx)

11. Press [(] [X,θ,T] [−] [1] [)]

    [(] [X,θ,T] [−] [5] [)]

    [SHIFT] [→] [1] [SHIFT] [→] [5]

12. Press [EXE] and your graph will appear on screen as follows: (Shading is automatic)



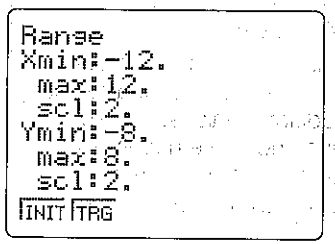
POLAR GRAPH

Setting the mode (In Rad mode)

1. Press [SHIFT] [1] [F2] [EXE] [SHIFT] [MENU (SET UP)] [F2]
   to specify the POL mode for drawing of a polar coordinate graph, and then press [EXIT] [EXIT]

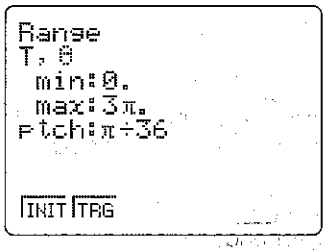
Setting the range

2. Press [AC/ON]
3. Set the range parameters to match the following screen.
   Remember to press [EXE] after each value to move the cursor to the next field.
   If you have trouble, refer back to page XIII.



Polar graph cont'd

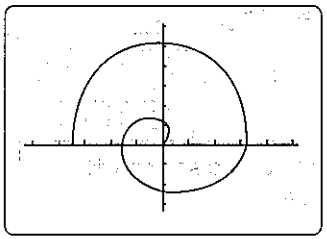
3. This time, we will also need to enter values in the second range screen. Set those to match the screen to the right.
   Remember to press [EXE] after each value is entered.



Creating the graph

EXAMPLE: $r = \theta$

4. Press [Graph] [X,θ,T] [EXE] and the graph will appear on the screen as follows:



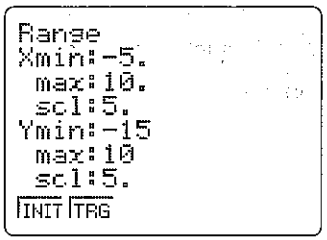
INEQUALITY GRAPH

Setting the mode

1. Press [SHIFT] [MENU (SET UP)] [F3] to specify the INEQ mode for drawing of an inequality graph, and then press [EXIT]

Setting the range

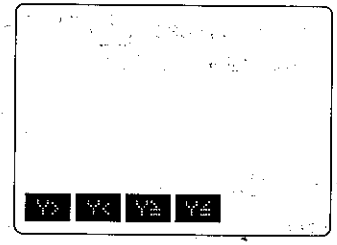
2. Press [AC/ON]
3. Set the range parameters to match the following screen.
   Remember to press [EXE] after each value to move the cursor to the next field.
   When the second range screen appears, press [Range] to bypass it, as again it is unnecessary for this example.



Creating the graph

EXAMPLE: $y > x^2 - 5x - 5$
$y < x - 2$

3. Press [Graph] and the following screen will appear:



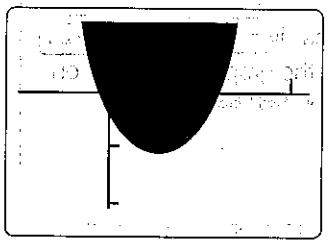
4. Press [F1] which corresponds to the Y> box on the screen.

5. Press [X,θ,T] [x^2]

[−] [5] [X,θ,T]

[−] [5] [EXE]

The following screen will appear:

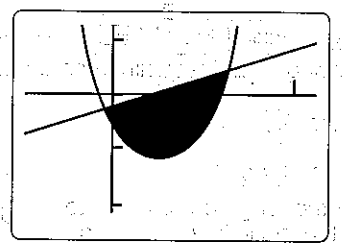


6. Press [Graph] to enter the next inequality.

7. Press [F2] which corresponds to the Y< box on the screen.

8. Press [X,θ,T] [−] [2]

[EXE]. The following screen will appear:



INPUTTING FUNCTIONS AND DRAWING GRAPHS

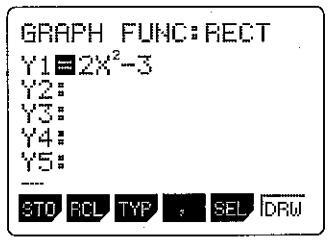
With the fx-7700GE, you first input the function of the graph, and then draw the graph using the function. Be sure to always specify the graph type before inputting the function.

EXAMPLE: $y = 2x^2 - 3$

Inputting the function

1. Select the GRAPH mode.
2. Press [SHIFT] [MENU (SET UP)] [F1] to specify the REC mode for drawing of a rectangular coordinate graph, and then press [EXIT].
3. Press [2] [X,θ,T] [x^2] [−] [3].
4. Press [F1] [F6].

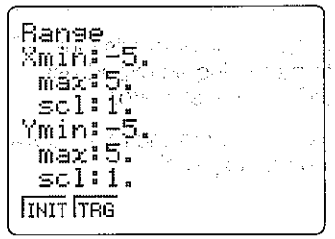
The following screen will appear:



Setting the range

5. Press [AC/ON]
6. Set the range parameters to match the following screen.

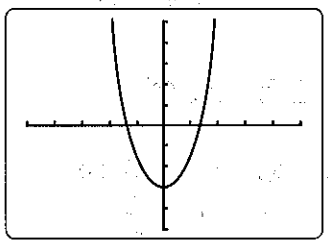
Remember to press [EXE] after each value to move the cursor to the next field. When the second range screen appears, press [Range] to bypass it, as again it is unnecessary for this example.



Drawing the graph of the function

7. Press [F6]

The graph will appear on the screen as follows:

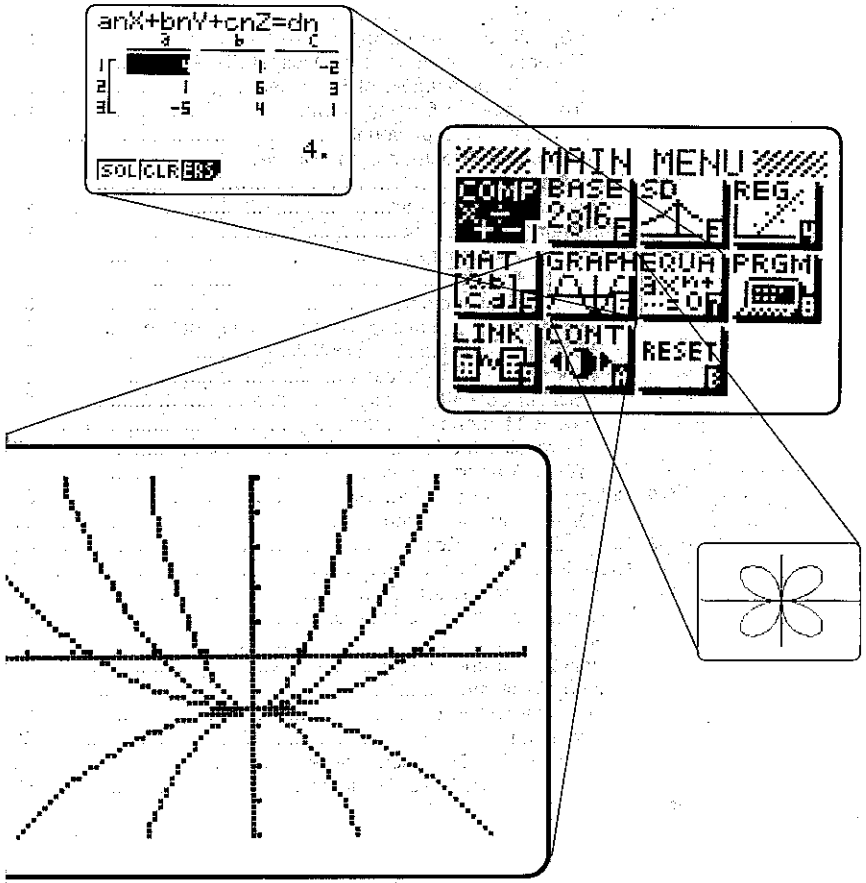


If you've completed this Quick-Start section, you are well on your way to becoming an expert user of the CASIO fx-7700GE PowerGraphic Calculator.

To learn all about the many powerful features of the fx-7700GE, read on and explore!

POWER GRAPHIC

fx-7700GE



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Handling Precautions

- Your calculator is made up of precision components. Never try to take it apart.
- Avoid dropping your calculator and subjecting it to other strong impacts.
- Do not store the calculator or leave it in areas exposed to high temperatures or humidity, or large amounts of dust. When exposed to low temperatures, the calculator may require more time to display results and may even fail to operate. Correct operation will resume once the calculator is brought back to normal temperature.
- The display will go blank and keys will not operate during calculations. When you are operating the keyboard, be sure to watch the display to make sure that all your key operations are being performed correctly.
- Replace batteries once every 2 years regardless of how much the calculator is used during that period. Never leave dead batteries in the battery compartment. They can leak and damage the unit.
- Avoid using volatile liquids such as thinner or benzine to clean the unit. Wipe it with a soft, dry cloth, or with a cloth that has been dipped in a solution of water and a neutral detergent and wrung out.
- In no event will the manufacturer and its suppliers be liable to you or any other person for any damages, expenses, lost profits, lost savings or any other damages arising out of loss of data and/or formulas arising out of malfunction, repairs, or battery replacement. The user should prepare physical records of data to protect against such data loss.
- Never dispose of batteries, the liquid crystal panel, or other components by burning them.
- When the "Low battery" message appears on the display, replace the main power supply batteries as soon as possible.
- Be sure that the power switch is set to OFF when replacing batteries.
- If the calculator is exposed to a strong electrostatic charge, its memory contents may be damaged or the keys may stop working. In such a case, perform the All Reset operation to clear the memory and restore normal key operation.
- Note that strong vibration or impact during program execution can cause execution to stop or can damage the calculator's memory contents.
- Using the calculator near a television or radio can cause interference with TV or radio reception.
- Before assuming malfunction of the unit, be sure to carefully reread this manual and ensure that the problem is not due to insufficient battery power, programming or operational errors.

Important

In no event shall CASIO Computer Co., Ltd. be liable to anyone for special, collateral, incidental, or consequential damages in connection with or arising out of the purchase or use of these materials. Moreover, CASIO Computer Co., Ltd. shall not be liable for any claim of any kind whatsoever against the use of these materials by any other party.

- The contents of this manual are subject to change without notice.
- No part of this manual may be reproduced in any form without the express written consent of the manufacturer.
- The options described in Chapter 9 of this manual may not be available in certain geographic areas. For full details on availability in your area, contact your nearest CASIO dealer or distributor.

About This Manual.....

This manual is divided into chapters to help you find the operation you want quickly and easily.

Chapter 1 Getting Acquainted

This chapter gives you a general introduction to the various capabilities of the unit. It contains important information about the unit, so you should be sure to read it before starting operation.

Chapter 2 Manual Calculations

Manual calculations are those that you input manually, as on the simplest of calculators. This chapter provides various examples to help you become familiar with the manual calculations.

Chapter 3 Differential and Integration Calculations

This chapter tells you how to perform differential and integration calculations on this unit.

Chapter 4 Statistical Calculations

This chapter tells you how to perform single-variable statistical calculations using standard deviation, and paired-variable statistical calculations using regression. No matter what type of statistical calculations you decide to perform, you can tell the unit to either store the statistical data or not to store the data.

Chapter 5 Using the Matrix Mode

This chapter tells you how to perform the calculations with five variable matrices (Mat A through Mat E) and a special matrix answer memory (Mat Ans).

Chapter 6 Equation Calculation

This chapter explains how to solve linear equations with two or three unknowns, and how to solve quadratic equations.

Chapter 7 Graphing

This chapter explains everything you need to know to fully use the versatile graphing capabilities of the unit.

Chapter 8 Programming

This chapter tells you how to use the program memory of the unit. Once you program a calculation, you can call it up and execute it using any values you want at the touch of a key.

Chapter 9 Data Communications

This chapter tells you everything you need to know to transfer programs between the fx-7700GE and another CASIO Power Graphic unit or between your fx-7700GE and a personal computer.

Appendix

The appendix contains information on battery replacement, error messages, specifications, and other technical details.

Important

Reset your calculator before using it for the first time!
See page 261 for details on the reset procedure.

Be sure to keep physical records of all important data!
The large memory capacity of the unit makes it possible to store large amounts of data. You should note, however, that low battery power or incorrect replacement of the batteries that power the unit can cause the data stored in memory to be corrupted or even lost entirely. Stored data can also be affected by strong electrostatic charge or strong impact.

Chapter 1

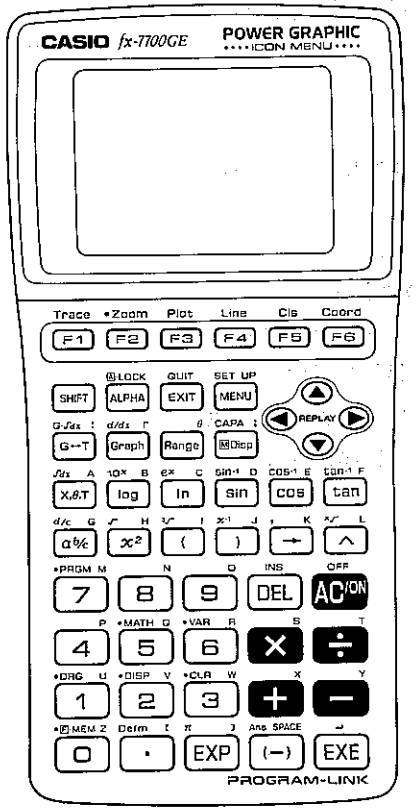
Getting Acquainted

1-1 Keys and Their Functions
1-2 Modes
1-3 Basic Set Up
1-4 Basic Operation
1-5 Using the Function Memory
1-6 Using the BASE Mode
1-7 Graphic and Text Displays
1-8 Technical Information

Chapter 1 Getting Acquainted

This chapter gives you a general introduction to the various capabilities of the unit. It contains important information about the unit, so you should be sure to read it before starting operation.

1-1 Keys and Their Functions



■The Keyboard

Many of the unit's keys are used to perform more than one function. The functions marked on the keyboard are color coded to help you find the one you need quickly and easily.

Shifted function (orange) —— 10^x B — Alpha function (red)
Primary function —— log

Also note that green markings show the names of menus that appear when the SHIFT is pressed.

• Primary Functions

These are the functions that are normally executed when you press the key.

• Shifted Functions

You can execute these functions by first pressing the SHIFT key, followed by the key that is assigned the shifted function you want to execute.

• Alpha Functions

An alpha function is actually the simple input of an alphabetic letter. Press the ALPHA key, followed by the key that is assigned the letter you want to input.

Alpha Lock

Normally, once you press ALPHA and then a key to input an alphabetic character, the keyboard reverts to its primary functions immediately. If you press SHIFT and then ALPHA, the keyboard locks in alpha input until you press ALPHA again.
Also note that green markings show the names of menus that appear when the SHIFT is pressed.

■Key Operations

Trace F1 ~ Coord F6 **Function Keys**

- Use these keys to select the functions indicated above them on the display.
- After drawing a graph, use these keys to access the built in graphic functions marked above them on the panel.

SHIFT **Shift Key**

- Press this key to shift the keyboard and access the functions marked in orange (or green). The S indicator on the display indicates that the keyboard is shifted. Pressing SHIFT again unshifts the keyboard and clears the S indicator from the display.
- This key is also used during display of a Mode Menu to advance to the next Mode Menu screen.

LOCK ALPHA **Alpha Key**

- Press this key to input a letter marked in red on the keyboard.
- Press this key following SHIFT to lock the keyboard into alphabetic character input. To return to normal input, press ALPHA again.

QUIT
[EXIT] Exit/Quit Key

- Press this key to back step through displays, from a display reached by pressing func tion keys.
- Pressing this key while a calculation result is displayed switches to the display from whicl the function was selected to perform the calculation.
- Press this key following [SHIFT] to quit an operation and return to the initial screen of the mode you are currently in.

SET UP
[MENU] Menu/Set Up Key

- Press this key to display the Main Menu.
- Press this key following [SHIFT] while a set up display is shown to change to the set up edi display.

[▲] [◀] REPLAY [▶] [▼] Cursor/Replay Keys

- Use these keys to move the cursor on the display.
- After you press the [EXE] key following input of a calculation or value, press [◀] to displa the calculation from the end, or [▶] to display it from the beginning. You can then exe cute the calculation again, or edit the calculation and then execute it. See page 32 fo details on the Replay Function.

G↔T
[G↔T] Graphic ↔ Text/Integration Graph Key

- Press this key to switch between the graphic display and text display.
- Press this key following [SHIFT] when you want to draw an integration graph.

d/dx r
[Graph] Graph/Differential Key

- Press this key before entering a calculation formula for graphing.
- Press this key following [SHIFT] when you want to perform differential calculations (page 70
- Press this key following [ALPHA] to enter the letter *r*.

θ
[Range] Range Key

- Use this key to set or check the range of a graph.
- Press this key following [ALPHA] to enter the letter *θ*.

CAPA
[M-Disp] Mode Display/Screen Copy/Capacity Key

- When this key is set to function as a Mode Display Key (page 38), it can be used t check the current set up display settings. The settings remain displayed while this ke is depressed.
- When this key is set to function as a Screen Copy Key, pressing it sends a bit patter of the current display image to a connected personal computer (page 255).
- When this key is set to function as a Mode Display Key, press this key following [SH to check the current status of the unit's memory capacity. The capacity remains di played while this key is depressed.

∫dx A
[X,θ,T] Variable/Integration Key

- Press this key to input variables X, *θ*, and T when setting up a graph.
- Press this key following [SHIFT] to input variables for integration calculations.
- Press this key following [ALPHA] to enter the letter A.

10^x B
[log] Common Logarithm/Antilogarithm Key

- Press this key and then enter a value to calculate the common logarithm of the value.
- Press [SHIFT][10^x] and then enter a value to make the value an exponent of 10.
- Press this key following [ALPHA] to enter the letter B.

e^x C
[ln] Natural Logarithm/Exponential Key

- Press this key and then enter a value to calculate the natural logarithm of the value.
- Press [SHIFT][e^x] and then enter a value to make the value an exponent of *e*.
- Press this key following [ALPHA] to enter the letter C.

sin⁻¹ D cos⁻¹ E tan⁻¹ F
[sin] [cos] [tan] Trigonometric Function Keys

[sin]
- Press this key and then enter a value to calculate the sine of the value.
- Press this key following [ALPHA] to enter the letter D.

[cos]
- Press this key and then enter a value to calculate the cosine of the value.
- Press this key following [ALPHA] to enter the letter E.

[tan]
- Press this key and then enter a value to calculate the tangent of the value.
- Press this key following [ALPHA] to enter the letter F.

[SHIFT][sin]
- Perform this operation and then enter a value to calculate the inverse sine of the value.

[SHIFT][cos]
- Perform this operation and then enter a value to calculate the inverse cosine of the value.

[SHIFT][tan]
- Perform this operation and then enter a value to calculate the inverse tangent of the value.

d/c G
[a b/c] Fraction Key

- Use this key when entering fractions and mixed fractions. To enter the fraction 23/45, for example, press 23[a b/c]45. To enter 2-3/4, press 2[a b/c]3[a b/c]4.
- Press [SHIFT][d/c] to display an improper fraction.
- Press this key following [ALPHA] to enter the letter G.

H
[x²] Square/Square Root Key

- Enter a value and press this key to square the entered value.
- Press [SHIFT][√] and then enter a value to calculate the square root of the value.
- Press this key following [ALPHA] to enter the letter H.

I
[(] Open Parenthesis/Cube Root Key

- Press this key to enter an open parenthesis in a formula.
- Press [SHIFT][∛] and then enter a value to calculate the cube root of the value.
- Press this key following [ALPHA] to enter the letter I.

J
[)] Close Parenthesis/Reciprocal Key

- Press this key to enter a close parenthesis in a formula.

A313025-28

•Press [SHIFT][x⁻¹] and then enter a value to calculate the reciprocal of the value.
•Press this key following [ALPHA] to enter the letter J.

K [→] Assignment/Comma Key

•Press this key before entering a value memory name to assign the result of a calculation to the value memory.
•Press this key following [SHIFT] to input a comma.
•Press this key following [ALPHA] to enter the letter K.

L [^] Power/Root Key

•Enter a value for x, press this key, and then enter a value for y to calculate x to the power of y.
•Enter a value for x, press [SHIFT][√], and then enter a value for y to calculate the xth root of y.
•Press this key following [ALPHA] to enter the letter L.

MEM Z, θ Defm [0]~[9], [·] Numeric Keys and Decimal Key

•Use the numeric keys to enter a value. Enter decimals using the decimal key.
•Following operation of the [ALPHA] key, each of the numeric keys enters the following letters.

[ALPHA][7] enters M.	[ALPHA][1] enters U.
[ALPHA][8] enters N.	[ALPHA][2] enters V.
[ALPHA][9] enters O.	[ALPHA][3] enters W.
[ALPHA][4] enters P.	[ALPHA][0] enters Z.
[ALPHA][5] enters Q.	[ALPHA][·] enters the open bracket [.
[ALPHA][6] enters R.	

•Following operation of the [SHIFT] key, the menus marked in green (or orange) above these keys are accessed.

[SHIFT][FMEM] — Function Memory Menu
This key operation displays the menu used for function memory calculations (see page 39).

[SHIFT][DRG] — Unit of Angular Measurement Menu
This key operation displays the menu used for specification of the unit of angular measurement.

[SHIFT][DISP] — Display Format Menu
This key operation displays the menu used for specification of the display format for calculation results.

[SHIFT][CLR] — Clear Menu
This key operation displays the menu used for clearing memory contents.

[SHIFT][MATH] — Built-In Function Menu
This key operation displays the menu used for specification of built-in functions and the engineering symbols (k, μ, etc.)

[SHIFT][VAR] — Variable Data Menu
This key operation displays the menu used for specification of variables used in graphic functions.

[SHIFT][PRGM] — Program Command Menu
This key operation displays the menu used for specification of special built-in program functions.

[SHIFT][Defm][EXE]
This key sequence displays the status of the program, function, variable, statistic (SD and LR), and matrix memories, along with the remaining number of bytes.

For full details on each menu, see the section titled "Basic Set Up", "Basic Operation" starting from page 23.

OFF [AC/ON] All Clear/ON/OFF Key

•Press this key to switch power on.
•Press this key while power is on to clear the display.
•Press this key following [SHIFT] to switch power off.

INS [DEL] Delete/Insert Key

•Press this key to delete the character at the current cursor location.
•Press [SHIFT][INS] to display the insert cursor ([ ]). You can insert characters while the insert cursor is displayed.

X [+] Y [−] S [×] T [÷] Arithmetic Operation Keys

•Input addition, subtraction, multiplication, and division calculations as they are written, from left to right. Press the applicable key to specify an arithmetic operation.
•You can also use the [+] and [−] keys to specify positive and negative values.
•Following operation of the [ALPHA] key, each of these keys enters the following letters.
[ALPHA][×] enters S.
[ALPHA][÷] enters T.
[ALPHA][+] enters X.
[ALPHA][−] enters Y.

π] [EXP] Exponent/Pi Key

•Use this key when entering a mantissa and exponent. To input 2.56×10^{34}, for example, enter 2.56[EXP]34.
•Press [SHIFT][π] to input the value of π.
•Press this key following [ALPHA] to enter the closed bracket].

SPACE [(−)] (−)/Answer/Space Key

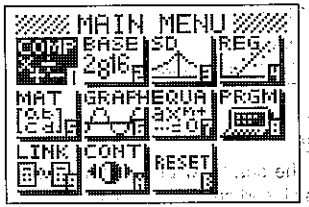
•Press this key when entering a negative value.
•Press [SHIFT] and then this key to recall the most recent calculation result obtained using the [EXE] key.
•Press [ALPHA] and then this key to enter a space.

[EXE] Execute/Newline Key

•Press this key to obtain the result of a calculation. You can press this key following data input, or after a result is obtained to execute the calculation again using the previous result.
•Press [SHIFT][↵] to perform a newline operation.

1-2 Modes

You can control the operations of the unit by entering the correct *mode*. To select th mode you need, select the appropriate icon from the *Main Menu*. The Main Menu appear whenever you press the [MENU] key.



The icon that is highlighted is the one that is currently *selected*. Use the cursor keys move the highlighting around the display to select the mode that you want. To enter th highlighted mode, press the [EXE] key.
The following explains the meaning of each icon in the Main Menu.

COMP Mode
Use this mode for arithmetic calculations and function calculations, for drawin graphs and for executing programs.

BASE Mode
Use this mode for binary, octal, decimal, and hexadecimal calculations and co versions. This mode is also used for logical operations.

SD Mode
Use this mode for single-variable statistical calculations (standard deviation).

REG Mode
Use this mode for paired-variable statistical calculations (regression).

MAT Mode
Use this mode for matrix calculations.

GRAPH Mode
Use this mode to input functions and draw their graphs.

EQUA Mode
Use this mode to solve quadratic equations, and linear equations with two or thre unknowns.

PRGM Mode
Use this mode for writing, reading, and executing programs.

LINK Mode
Use this mode to transfer program, function, matrix, and other memory data to another unit.

CONT Mode
Use this mode to adjust the display contrast.

RESET Mode
Use this mode to reset the calculator to its initial parameters.

■Set Up Displays

Except for the LINK, CONT, and RESET modes, entering a mode causes a *set up display* to appear first. The set up displays show the current status of other modes that are related to the mode you entered. How a mode is set up affects the calculation results produced in the mode.
The status shown in each set up display shows initial settings that are in effect whenever the RESET operation (page 261) is performed.

• To change a set up

Select the COMP Mode icon and press [EXE] to display the set up display.

```
    RUN / COMP
G-type  : REC/CON
angle   : Deg
display:Nrml
M-D/Cpy: M-Disp
```

Press [SHIFT] [SETUP] to switch to the set up edit display.

```
▶GRAPH TYPE:REC
 DRAW TYPE :CON
 M-DSP/COPY:M-DP

REC POL PRM INQ
```

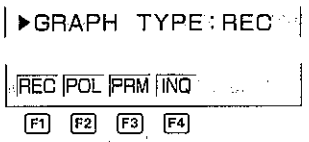
[F1] [F2] [F3] [F4]

Use the ▲ and ▼ cursor keys to move the pointer to the line whose set up you want to change.
Press the function key that corresponds to the setting that you want to make.
Make the other changes.
Press [EXIT] to return to the set up display.

Set Up Display Function Key Menus

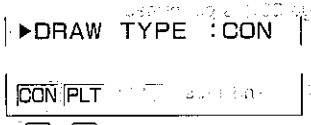
This section details the settings that you can make using the function keys in the set u edit display.

•Graph Type (GRAPH TYPE)



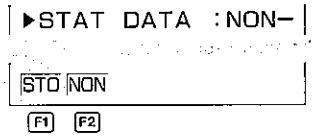
F1(REC) ..... Rectangular coordinate graph
F2(POL) ..... Polar coordinate graph
F3(PRM) ..... Parametric graph
F4(INQ) ..... Inequality graph

•Graph Drawing Type (DRAW TYPE)



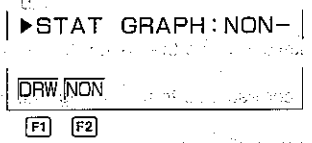
F1(CON) ..... Connection of plotted points
F2(PLT) ..... No connection of plotted points

•Statistical Data Storage (STAT DATA)



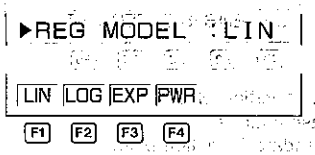
F1(STO) ..... Storage of input statistical data into statistical data memory
F2(NON) ..... No storage of input statistical data into statistical data memor

•Statistical Graph Drawing (STAT GRAPH)



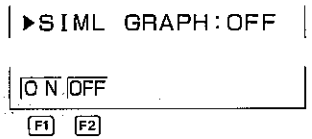
F1(DRW) ..... Drawing of graph using single-variable or paired-variable calculation results
F2(NON) ..... No drawing of graph using single-variable or paired-variable calculation results

•Paired-Variable Statistic Calculation (REG MODEL)



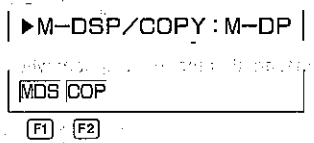
F1(LIN) ..... Linear regression
F2(LOG) ..... Logarithmic regression
F3(EXP) ..... Exponential regression
F4(PWR) ..... Power regression

•Simultaneous Graphing (SIML GRAPH)



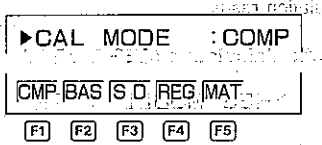
F1(ON) ..... Simultaneous drawing of graphs for functions stored in graph function memory
F2(OFF) ..... One-by-one drawing of graphs for functions stored in graph function memory

•[M·Disp] Key Setting (M-DSP/COPY)



F1(MDS) ..... Holding down [M·Disp] key shows set up display for current mode
F2(COP) ..... Pressing [M·Disp] enters a mode that makes it possible to transfer a bit pattern of the current display contents to a personal computer.

•After you select the PRGM Mode, you can use the set up display to sepecify the calcula tion mode (CAL MODE) for program execution. Whenever you change the calculatio mode, the contents of the set up display change accordingly.



F1(CMP) ..... Computation Mode
F2(BAS) ..... Base-*n* Mode
F3(SD) ..... Standard Deviation Mode
F4(REG) ..... Regression Mode
F6(MAT) ..... Matrix Mode

■About Function Key Icons

There are three types of function key icons that appear at the bottom of the display.

Example **MATRIX Mode**

F1(Mat)
⋮
F3(Trn)

This type of icon indicates that a function will be accessed (but not executed) when yo press the function key.

F4(LIST)

This type of icon indicates that another menu will appear when you press the function key

F5(SEE)

This type of icon indicates that a function will be executed as soon as you press the func tion key.

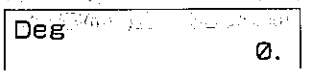
1-3 Basic Set Up

■To Specify the Unit of Angular Measurement

Example **To set the unit of angular measurement as degrees**

SHIFT DRG

F1(Deg) EXE



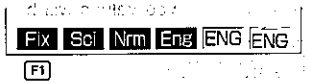
The relationship of the angular measurement units are:
360° = 2π radians = 400 grads
90° = π/2 radians = 100 grads

•Press EXIT to exit the angular unit setting mode.

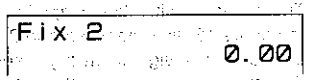
■To Specify the Number of Decimal Places

Example **To set the number of decimal places to 2**

SHIFT DISP



F1(Fix) 2 EXE



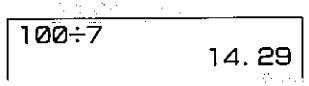
Now all displayed values will be rounded off to the nearest integer at the second decimal place.

Important

The above specification is applied to the displayed value only. The calculator still stores the entire 13-digit mantissa and 2-digit exponent of the result in memory. If you change the number of decimal places specification while a calculation result is displayed, the display changes to show the value using your new specification.

Example **To perform 100 ÷ 7 with 2 decimal places, and then change to 5 decimal places**

AC 1 0 0 ÷ 7 EXE



[SHIFT] [DISP]

Fix Sci Nrm Eng ENG ENG

[F1]

[F1](Fix) [5] [EXE]

Fix 5
14.28571

Note

No matter what settings are currently being applied for the number of decimal places, pressing [SHIFT] [DISP] [F3](Nrm) [EXE] returns to the Norm mode (1 or 2).

■To Specify the Number of Significant Digits

Example **To set the number of significant digits to 3**

[SHIFT] [DISP]

Fix Sci Nrm Eng ENG ENG

[F2]

[F2](Sci) [3] [EXE]

Sci 3
0.00E+00

Now all displayed values will be shown with 3 significant digits.

Important

The above specification is applied to the displayed value only. The calculator still stores the entire 13-digit mantissa and 2-digit exponent of the result in memory. If you change the number of significant digits specification while a calculation result is displayed, the display changes to show the value using your new specification.

Example **To perform 123 × 456 with 3 significant digits, and then change to 4 significant digits**

[AC] [1] [2] [3] [×] [4] [5] [6] [EXE]

123×456
5.61E+04

[SHIFT] [DISP]

Fix Sci Nrm Eng ENG ENG

[F2]

[F2](Sci) [4] [EXE]

Sci 4
5.609E+04

Note

No matter what settings are currently being applied for the number of significant digits, pressing [SHIFT] [DISP] [F3](Nrm) [EXE] returns to the Norm mode (1 or 2).

■To Specify the Display Format

[SHIFT] [DISP]

Fix Sci Nrm Eng ENG ENG

[F3]

[F3](Nrm) [EXE]

Norm
0.

Each time you press [SHIFT] [DISP] [F3](Nrm) [EXE], the display format changes between Norm 1 and Norm 2. See page 51 for full details on Norm 1 and Norm 2.

Important

The above specification is applied to the displayed value only. The calculator still stores the entire 13-digit mantissa and 2-digit exponent of the result in memory. If you change the display format specification while a calculation result is displayed, the display changes to show the value using your new specification.

Example **To perform 1 ÷ 200 with Norm 1, and then change to Norm 2**

[AC] [1] [÷] [2] [0] [0] [EXE]

1÷200
5.E-03

Norm 1

[SHIFT] [DISP] [F3](Nrm) [EXE]

Norm
0.005

Norm 2

[SHIFT] [DISP] [F3](Nrm) [EXE]

Norm
5.E-03

Norm 1

■To Specify the Engineering Mode

[SHIFT] [DISP]

Fix Sci Nrm Eng ENG ENG

[F4]

[F4](Eng) [EXE]

Eng
5.m

Each time you press [SHIFT] [DISP] [F4](Eng) [EXE], the unit enters or exits the Engineering Mode.

•Press [EXIT] to exit the engineering mode setting mode.

Important

The above specification is applied to the displayed value only. The calculator still store the entire 13-digit mantissa and 2-digit exponent of the result in memory. If you chang the engineering mode specification while a calculation result is displayed, the displ changes to show the value using your new specification.

Example **To perform 1÷500 in Norm 1, and then change to the Engineerin Mode**

[AC] [1] [÷] [5] [0] [0] [EXE]

1÷500
2. E-03

[SHIFT] [DISP]

Fix Sci Nrm Eng ENG ENG
[F4]

[F4](Eng)[EXE]

Eng
2.-

[F4](Eng)[EXE]

Eng
2. E-03

■To Adjust the Contrast of the Display

Highlight the **CONT** icon on the Main Menu.

[MENU]

[◀] [▶]

[EXE](or [X,θ,T])

```
**********
*  CONTRAST  *
**********
LIGHT      DARK
 [←]       [→]
```

[◀] make the screen lighter
[▶] to make the screen darker
[MENU] to return to the Main Menu

Important

If the display remains dim even when you adjust the contrast, you should replace batte ies as soon as possible.

1-4 Basic Operation

The operations described here are fundamental calculations that you need to get started with the unit. Graphing, programming, and statistical calculations are covered in their own separate sections.

■Using the Clear Menu

The Clear Menu lets you clear either the entire memory of the unit or specific parts of the memory.

Important

- The procedures described below cannot be undone. Make sure that you do not need data any more before you delete it.
- You can call up the Clear Menu while the unit is in any mode.

• To clear the entire memory

[SHIFT] [CLR]

Mcl Scl
[F1]

[F1](Mcl)[EXE]

Mcl
0.

This operation clears all of the value memories, as well as any values assigned to r, θ, and variables.

• To clear statistical memories only

[SHIFT] [CLR]

Mcl Scl
[F2]

[F2](Scl)[EXE]

Scl
0.

- This operation clears any values assigned to Σx^2, Σx, n, Σy^2, Σy, and Σxy.
- In the case of single-variable statistics (SD Mode), if the statistical graph drawing type (STAT GRAPH) is set to "DRAW," the clear operation clears bar graph memory θ.
- Press [EXIT] to exit the memory clear mode.

■Inputting Calculations

When you are ready to input a calculation, first press [AC] to clear the display. Next, inp your calculation formulas exactly as they are written, from left to right, and press [EXE] obtain a result.

Example 1 2+3−4+10=

[AC][2][+][3][−][4][+][1][0][EXE]

```
2+3-4+10
                11.
```

Example 2 2(5+4)÷(23×5)=

[AC][2][(][5][+][4][)][÷]
[(][2][3][×][5][)][EXE]

```
2(5+4)÷(23×5)
   0.1565217391
```

The unit uses two types of functions: Type A functions and Type B functions. With Ty A functions, you press the function key after you enter a value. With Type B function you press the function key first and then enter a value.

Example 1 **(Type A function)**

	Example	Key Operation
Squares:	4^2	[4][x^2]

Example 2 **(Type B function)**

	Example	Key Operation
Sine:	2 sin45°	[2][sin][4][5]

•For detailed examples on all of the possible calculations available, see the section titl "Calculation Priority Sequence" on page 47.

• To clear an entire calculation and start again

Press the [AC] key to clear the error along with the entire calculation. Next, re-input t calculation from the beginning.

■Editing Calculations

Use the [◀] and [▶] keys to move the cursor to the position you want to change, and the perform one of the operations described below. After you edit the calculation, you ca execute it by pressing [EXE], or use [▶] to move to the end of the calculation and input mor

• To change a step

Example **To change cos60 to sin60**

[cos][6][0]

```
cos 60_
```

[◀][◀][◀]

```
cos 60
```

[sin]

```
sin 60
```

• To delete a step

Example **To change 369×××2 to 369×2**

[3][6][9][×][×][2]

```
369××2_
```

[◀][◀][DEL]

```
369×2
```

• To insert a step

Example **To change 2.36^2 to $\sin 2.36^2$**

[2][•][3][6][x^2]

```
2.36²_
```

[◀][◀][◀][◀][◀]

```
2.36²
```

[SHIFT][INS]

```
2.36²
```

[sin]

```
sin 2.36²
```

•When you press [SHIFT][INS] a space is indicated by the symbol "␣". The next function or value you input is inserted at the location of "␣". To abort the insert operation without inputting anything, move the cursor, press [SHIFT][INS] again, or press [EXE].

• To make corrections in the original calculation

Example **14÷0×2.3 entered by mistake for 14÷10×2.3**

[AC][1][4][÷][0][×][2][•][3][EXE]

```
14÷0×2.3
 Ma ERROR
 Bytes    4
```

Press [◀] or [▶].

```
14÷0×2.3
```

Cursor is positioned automatically at the location of the cause of the error.

Make necessary changes.
◀ SHIFT INS 1

```
14÷10×2.3
```

Execute it again.
EXE

```
14÷10×2.3
                3.22
```

- The last calculation performed is not cleared even when you press the AC key. This means you can clear the display using AC and then recall the calculation.
- The last calculation performed is cleared whenever you press the EXE key to select a mode in the Main Menu.

■Answer Function

The unit's Answer Function automatically stores the last result you calculated by pressing EXE (unless the EXE key operation results in an error). The result is stored in the answer memory.

• To recall the contents of the answer memory

SHIFT Ans EXE

• To use the contents of the answer memory in a calculation

Example 123 + 456 = 579
789 − 579 = 210

AC 1 2 3 + 4 5 6 EXE

```
123+456
                579.
```

7 8 9 − SHIFT Ans EXE

```
789−Ans
                210.
```

- The largest value that the answer memory can hold is one with 13 digits for the mantissa and 2 digits for the exponent.
- Answer memory contents are not cleared when you press the AC key or when you switch power off.
- Note that answer memory contents are not changed by an operation that assigns value to value memory (such as: 5 → ALPHA A EXE).

■Using Multistatements

Multistatements are formed by connecting a number of individual statements for sequential execution. You can use multistatements in manual calculations and in programmed calculations. There are three different ways that you can use to connect statements to form multistatements.

•Colon (:)

Statements that are connected with colons are executed from left to right, without stopping.

•Display Result Command(◢)

When execution reaches the end of a statement followed by a display result command, execution stops and the result up to that point appears on the display. You can resume execution by pressing the EXE key.

•Newline Operation

The newline operation ends the line you are currently inputting, and moves the cursor to the next line. When execution reaches the end of a line where a newline operation was performed, the unit treats the end of the line like a colon (multistatement connector).

• To use multistatements

Example 6.9 × 123 = 848.7
123 ÷ 3.2 = 38.4375

AC 1 2 3 → ALPHA A SHIFT PRGM
F6 (:) 6 • 9 × ALPHA A
F5 (◢) ALPHA A ÷ 3 • 2 EXE

```
123→A:6.9×A◢
A÷3.2
                848.7
              —Disp—
```

Appears on display when "◢" is used.

EXE

```
123→A:6.9×A◢
A÷3.2
                848.7
               38.4375
```

- Note that the final result of a multistatement is always displayed, regardless of whether it ends with a display result command.
- You cannot construct a multistatement in which one statement directly uses the result of the previous statement.

Example 123 × 456 : × 5
Invalid

■Multiplication Operations without a Multiplication Sign

You can omit the multiplication sign (×) in any of the following operations.

- Before the type B functions (page 48) and coordinate transformation functions:

Example 2sin30, 10log1.2, 2√3, 2pol(5, 12), etc.

- Before constants, variable names, value memory names

Example 2π, 2AB, 3Ans, 3Y1, 4Sim X, etc.

- Before an open parenthesis

Example 3(5 + 6), (A + 1)(B − 1), etc.

■Performing Continuous Calculations

The unit lets you use the result of one calculation as one of the arguments in the nex calculation. The precision of such calculations is 10 digits (for the mantissa).

Example $3 \times 4 = 12$
$12 \div 3.14 = 3.821656051$

[AC] [3] [×] [4] [EXE]

```
3×4
                12.
```

(Continuing) [÷] [3] [•] [1] [4] [EXE]

```
12.÷3.14
          3.821656051
```

Continuous calculations can also be used with Type A functions (see page 47).

■Using the Replay Function

The Replay Function automatically stores the last calculation performed in replay memor You can recall the contents of the replay memory by pressing ◀ or ▶. If you press ▶ the calculation appears with the cursor at the beginning. Pressing ◀ causes the calcu lation to appear with the cursor at the end. You can make changes in the calculation a you wish and then execute it again.

Example **To perform the following two calculations**
$4.12 \times 3.58 + 6.4 = 21.1496$
$4.12 \times 3.58 - 7.1 = 7.6496$

[AC] [4] [•] [1] [2] [×] [3] [•] [5] [8] [+] [6] [•] [4] [EXE]

```
4.12×3.58+6.4
              21.1496
```

[◀]

```
4.12×3.58+6.4_
```

[◀] [◀] [◀] [◀]

```
4.12×3.58+6.4
```

[−] [7] [•] [1]

```
4.12×3.58−7.1_
```

[EXE]

```
4.12×3.58−7.1
              7.6496
```

- The maximum capacity of the replay memory is 127 bytes.
- The contents of the replay memory are retained even if you press [AC] or switch power o

Example

[AC] [1] [2] [3] [×] [4] [5] [6] [EXE]

```
123×456
              56088.
```

[AC]

```
_
```

[◀]

```
123×456_
```

- The contents of the replay memory are cleared whenever you change from one menu to another.

■Built-in Scientific Functions

In addition to the scientific functions that you can access directly from the keyboard, this calculator also provides a selection of other built-in functions. Use the MATH Menu to access these built-in functions.

• To call up the MATH Menu

[SHIFT] [MATH]

```
HYP PRB NUM DMS COR SYM
 F1  F2  F3  F4  F5  F6
```

Press the function key to call up the sub-menu that contains the type of operation you want to perform.

- [F1](HYP) ..... Hyperbolic Function Menu for hyperbolic and inverse hyperbolic functions
- [F2](PRB) ..... Probability Function Menu for factorials, permutations, combinations, and random numbers
- [F3](NUM) ..... Numeric Function Menu for absolute value calculations, integer and decimal part extractions, and internal rounding
- [F4](DMS) ..... Sexagesimal Function Menu for degree, minute, second inputs and conversions
- [F5](COR) ..... Coordinate Function Menu for rectangular and polar coordinate transformations
- [F6](SYM) ..... Engineering Symbol Menu for engineering symbols

- Press [EXIT] to back step to the previous display.

• To use the Hyperbolic Function Menu

[SHIFT] [MATH]

```
HYP PRB NUM DMS COR SYM
 F1
```

[F1](HYP)

```
sinh cosh tanh sinh⁻¹ cosh⁻¹ tanh⁻¹
 F1   F2   F3   F4    F5     F6
```

Press the function key below the hyperbolic function you want to input.

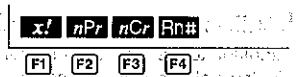
- [F1](snh) ..... hyperbolic sine
- [F2](csh) ..... hyperbolic cosine
- [F3](tnh) ..... hyperbolic tangent
- [F4](snh^{-1}) ..... inverse hyperbolic sine
- [F5](csh^{-1}) ..... inverse hyperbolic cosine
- [F6](tnh^{-1}) ..... inverse hyperbolic tangent

•Press [EXIT] to back step to the MATH Menu.

• To use the Probability Function Menu

[SHIFT] [MATH]

[F2](PRB)



Press the function key below the probability function you want to input.

- [F1](*x*!) ..... factorial of *x*
- [F2](*n*P*r*) ..... permutation
- [F3](*n*C*r*) ..... combination
- [F4](Rn#) ..... random number generation

•Press [EXIT] to back step to the MATH Menu.

• To use the Numeric Function Menu

[SHIFT] [MATH]

[F3](NUM)

Press the function key below the numeric function you want to input.

- [F1](Abs) ..... absolute value
- [F2](Int) ..... integer extraction
- [F3](Frc) ..... fraction extraction
- [F4](Rnd) ..... rounding*
- [F5](Intg) ..... maximum value that does not exceed argument

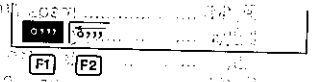
*Rounds the internal value to 10 significant digits. The sam rounding is applied to the Ans memory contents. In the F mode, the internal value is cut off in accordance with the F specification. In the Sci mode, the internal value is cut off s the number of significant digits is in accordance with the S mode specification.

•Press [EXIT] to back step to the MATH Menu.

• To use the Sexagesimal Function Menu

[SHIFT] [MATH]

[F4](DMS)



Press the function key below the sexagesimal function you want to input.

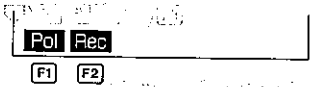
- [F1](° ' ") ..... For input of hours, minutes and seconds, or degrees, minutes and seconds as sexagesimal values
- [F2](d.dd) ..... For input of hours, minutes and seconds, or degrees, minutes and seconds as decimal values

•Press [EXIT] to back step to the MATH Menu.

• To use the Coordinate Function Menu

[SHIFT] [MATH]

[F5](COR)



Press the function key below the coordinate function you want to input.

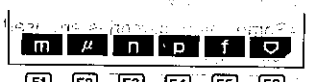
- [F1](Pol) ..... transformation of rectangular coordinates to polar coordinates
- [F2](Rec) ..... transformation of polar coordinates to rectangular coordinates

•Press [EXIT] to back step to the MATH Menu.

• To use the Engineering Symbol Menu

[SHIFT] [MATH]

[F6](SYM)



Press the function key below the engineering symbol you want to input.

- [F1](m) ..... milli (10^{-3})
- [F2](μ) ..... micro (10^{-6})
- [F3](n) ..... nano (10^{-9})
- [F4](p) ..... pico (10^{-12})
- [F5](f) ..... femto (10^{-15})
- [F6](▽) ..... advance to next menu

[F6](▽)

k	M	G	T	P	E
F1	F2	F3	F4	F5	F6

[F1](k) ..... kilo (10^3)
[F2](M) ..... mega (10^6)
[F3](G) ..... giga (10^9)
[F4](T) ..... tera (10^{12})
[F5](P) ..... peta (10^{15})
[F6](E) ..... exa (10^{18})

- Engineering symbols cannot be used inside of multistatements or programs.
- Press [EXIT] to back step to the previous menu.

• To use engineering symbols in calculations

Example 1000 m × 5 k

[AC][1][0][0][0][SHIFT][MATH][F6](SYM)
[F1](m)[×][5][F6](▽)[F1](k)[EXE]

```
1000m×5k
          5000.
```

■Value Memories

This calculator comes with 28 value memories as standard (which can be expanded u
to 528). You can use value memories to store values to be used inside of calculation
Value memories are identified by single-letter names, which are made up of the 26 lette
of the alphabet, plus *r* and *θ*. The maximum size of values that you can assign to valu
memories is 13 digits for the mantissa and 2 digits for the exponent. Value memory co
tents are retained even when you switch power off.

Important

- Some value memories are used by the unit for certain types of calculations. Note t
following.

Type of Calculation	Value Memories Used
Single-Variable Statistics (non-storage)	U, V, W
Paired-Variable Statistics (non-storage)	P, Q, R, U, V, W
Differentiation	F, G, H
Integration	K, L, M, N
Coordinate Conversion	I, J
Matrix Row Operations (swap, scalar products, addition)	K

You cannot assign values to these value memories while the above calculations are b
ing performed. You should also clear the value memories before starting the above op
ations. Be especially careful during programmed calculations to avoid problems caus
by values mistakenly assigned to memories that are used by the calculator.

• To assign a value to a value memory

Example To assign 123 to value memory A

[AC][1][2][3][→][ALPHA][A][EXE]

```
123→A
          123.
```

Example To add 456 to value memory A and store the result in value memory B

[AC][ALPHA][A][+][4][5][6][→][ALPHA][B][EXE]

```
A+456→B
          579.
```

• To display the contents of a value memory

Example To display the contents of value memory A

[AC][ALPHA][A][EXE]

```
A
          123.
```

• To clear a value memory

Example To clear value memory A

[AC][0][→][ALPHA][A][EXE]

```
0→A
          0.
```

• To clear all value memory contents

[AC][SHIFT][CLR][F1](Mcl)[EXE]

```
Mc l
          0.
```

■Increasing the Number of Value Memories

Though 28 value memories are provided as standard, you can configure the memory of
the unit to increase the number of value memories and decrease the amount of program
memory. Each additional value memory takes up eight bytes of program memory.

Number of Value Memories	28	29	30	31	·····	528
Number of Program Memory Bytes	4000	3992	3984	3976	·····	0

The maximum number of value memories possible is 528 (an increase of 500).

Important

- You may not be able to increase the number of value memories to the level you wa if the memory already contains programs, matrices, function memory contents, or statis cal data. If there is not enough unused memory available to increase to the number yo specify, an error message will appear on the display.
- The [SHIFT] [Defm] specification can also be included within a program.

• To increase the number of value memories

Example **To increase the number of value memories by 30 (for a total of 28 30 = 58)**

[SHIFT] [Defm] [3] [0] [EXE]

```
①Prg:   0 Mem: 58④
②F-M:   0 Mat:  0⑤
③Grp:   0 SD :  0⑥
          REG:  0
          Sim:  0⑦
          Pol:  0
 3760 Bytes Free⑧
```

①Number of bytes used for programs
②Number of bytes used for function memory
③Number of bytes used for graphic function memory
④Number of available value memories
⑤Number of memories used for matrix calculations
⑥Number of memories used for statistical calculations
⑦Number of memories used for equation calculations
⑧Number of unused bytes remaining

- For ④, ⑤, ⑥, and ⑦, one memory uses eight bytes

• To check the current memory status

[SHIFT] [Defm] [EXE] (or hold down [M Disp])

• To initialize the number of value memories

[SHIFT] [Defm] [0] [EXE]

```
Prg:   0 Mem: 28
F-M:   0 Mat:  0
Grp:   0 SD :  0
         REG:  0
         Sim:  0
         Pol:  0
4000 Bytes Free
```


■ About Memory Names

You can use the additional memories you create from program memory just as you use the original 28. The names of the additional memories are Z[1], Z[2], Z[3], etc. If you increase the number of value memories by 5, you can access the original 28 memories, plus memories Z[1] through Z[5].

1-5 Using the Function Memory

You can store up to six functions in memory for instant recall when you need them. Function memory can be used in any mode except the BASE Mode.

• To display the Function Memory Menu

[SHIFT] [F] [MEM]

```
STO RCL fn LIST
 F1  F2  F3  F4
```

- The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.
  - [F1](STO) ..... Stores functions
  - [F2](RCL) ..... Recalls functions
  - [F3](fn) ..... Specifies input as a function. See page 197 for an example of [F3](fn) operation.
  - [F4](LIST) ..... Displays a list of stored functions
- Press [EXIT] to back step to the previous menu.

• To store a function

Example **To store the function (A + B) (A − B) as function memory number 3.**

[AC] [(] [ALPHA] [A] [+] [ALPHA] [B] [)] [(] [ALPHA] [A] [−] [ALPHA] [B] [)] [SHIFT] [F] [MEM]

```
(A+B)(A-B)_
```

```
STO RCL fn LIST
```

[F1]

[F1](STO)

```
STO RCL fn LIST
```

[3]

```
FUNCTION MEMORY
f1:
f2:
f3:(A+B)(A-B)
f4:
f5:
f6:
STO RCL fn LIST
```

•If the function memory number you assign a function to already contains a function, the previous function is replaced with the new one.

• To recall a function

Example **To recall function memory number 3**

[SHIFT] [F1 MEM]

STO RCL fn LIST

[F2]

[F2](RCL)

STO RCL fn LIST

[3]

(A+B)(A−B)_

•The recalled function appears at the current location of the cursor on the display.

• To display a list of available functions

[SHIFT] [F1 MEM]

STO RCL fn LIST

[F4]

[F4](LIST)

```
FUNCTION MEMORY
f1 :
f2 :
f3 : (A+B)(A−B)
f4 :
f5 :
f6 :
STO RCL fn LIST
```

• To delete a function

Example **To delete function memory number 3**

STO RCL fn LIST

[SHIFT] [F1 MEM] [AC] [F1](STO)

[3]

```
FUNCTION MEMORY
f1 :
f2 :
f3 :
f4 :
f5 :
f6 :
STO RCL fn LIST
```


•Executing the store operation while the display is blank deletes the function for the Function Memory you specify.

■VAR (Variable) Menu

The VAR Menu makes it easy for you to quickly recall graphic functions, equations, coefficients, solutions and other data from memory.

• To display the VAR Menu

[SHIFT] [VAR]

GRP SIM PLY

[F1] [F2] [F3]

The following are the data types that can be selected from the function menu at the bottom of the display. Press the function key below the data type you want to specify.

[F1](GRP) ..... Graphic functions that can be used to draw graphs in the Graph Mode

[F2](SIM) ..... Coefficients and solutions for simultaneous linear equations

[F3](PLY) ..... Coefficients and solutions for quadratic equations

•In the case of coefficients and solutions for simultaneous linear equations, you can only specify the newest memory data, either for linear equations with two unknowns or linear equations with three unknowns. Also note that changing the number of unknowns for simultaneous linear equations causes coefficients and solutions for the previous number of unknowns to be deleted.

•Press [EXIT] to back step to the previous display.

• To recall a graphic function

[SHIFT] [VAR] [F1](GRP)

Y r Xt Yt

[F1] [F2] [F3] [F4]

The following are the graph types that can be selected from the function menu at the bottom of the display. Press the function key below the graph type you want to recall.

[F1](Y) ..... Press [F1] before inputting a value that identifies a rectangular coordinate graph function.

[F2](r) ..... Press [F2] before inputting a value that identifies a polar coordinate graph function.

[F3](Xt) ..... Press [F3] before inputting a value that identifies an Xt parametric graph function.

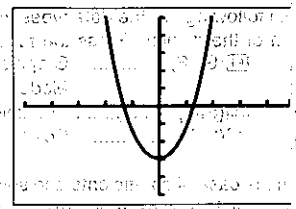
[F4](Yt) ..... Press [F4] before inputting a value that identifies an Yt parametric graph function.

•Press [EXIT] to back step to the previous display.

Example To recall the rectangular function $y = 2x^2 - 3$, which is stored i memory location Y2 using the following range parameters:

```
Range
Xmin:-5.
 max:5.
 scl:1.
Ymin:-5.
 max:5.
 scl:1.
INIT TRG
```

Graph SHIFT VAR F1(GRP) F1(Y) 2 EXE



Draw the graph using the procedures described on page 167.

• To recall coefficients and solutions for simultaneous linear equations

SHIFT VAR F2(SIM)

```
X  Y  Z  Coe
F1 F2 F3 F4
```

The following are the data types that can be selected from the function menu at the bo tom of the display. Press the function key below the data type you want to recall.

F1(X) ..... Recalls solution for X for a simultaneous linear equation
F2(Y) ..... Recalls solution for Y for a simultaneous linear equation
F3(Z) ..... Recalls solution for Z for a simultaneous linear equation
F4(Coe) ..... Recalls coefficients for a simultaneous linear equation in matri form (and also enters the recalled data into the Ans matri

•F4 (Coe) only appears when this menu is displayed in the MAT Mode.
•Press EXIT to back step to the previous display.

Example 1 To add 3 as a solution for X for a simultaneous linear equation (Sim = 8).

SHIFT VAR F2(SIM)

F1(X) + 3 EXE

```
Sim X+3
        11.
```


Example 2 To recall the coefficients for simultaneous linear equations: $3x + 2y = 3$, and $2x + 3y = 3$.

SHIFT VAR F2(SIM)

F4(Coe) EXE

```
Ans   1   2   3
1[    3   2   3]
2[    2   3   3]
                3.
X  Y  Z  Coe
```

• To recall coefficients and solutions for quadratic equations

SHIFT VAR F3(PLY)

```
X1 X2 Coe
F1 F2 F3
```

The following are the data types that can be selected from the function menu at the bottom of the display. Press the function key below the data type you want to recall.

F1(X1) ..... Recalls solution for X_1 for a quadratic equation
F2(X2) ..... Recalls solution for X_2 for a quadratic equation
F3(Coe) ..... Recalls coefficients for a quadratic equation in matrix form (and also enters the recalled data into the Ans matrix)

•F3 (Coe) only appears when this menu is displayed in the MAT Mode.
•Press EXIT to back step to the previous display.

Example 1 To apply 3 as a solution for X_1 for a quadratic equation (Ply $X_1 = 3$).

SHIFT VAR F3(PLY)

3 F1(X1) EXE

```
3Ply X1
        9.
```

Example 2 To recall the coefficients for quadratic equation: $x^2 + 8 + 2 = 0$.

SHIFT VAR F3(PLY)

F3(Coe) EXE

```
Ans   1   2   3
1[    1   8   2]
                1.
X1 X2 Coe
```

1-6 Using the BASE Mode

You can use the BASE Mode to perform calculations with binary, octal, decimal and hexadecimal values. You should also use this mode to convert between number systems and for logical operations.

- You cannot use scientific functions in the BASE Mode.
- You can use only integers in the BASE Mode, so fractional values are not allowed. If you input a value that includes a decimal part, the unit automatically cuts off the decimal.
- If you attempt to enter a value that is invalid in the number system (binary, octal, decimal, hexadecimal) you are using, the calculator displays an error message. The following show the numerals that can be used in each number system.

  Binary: 0, 1
  Octal: 0, 1, 2, 3, 4, 5, 6, 7
  Decimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
  Hexadecimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

- The alphabetic characters used in the hexadecimal number appear differently on the display to distinguish them from text characters.

  Normal Text: A, B, C, D, E, F
  Hexadecimal Values: 𝔸, 𝔹, ℂ, 𝔻, 𝔼, 𝔽

- Negative binary, octal, and hexadecimal values are produced using the two's complement of the original value.
- The following are the display capacities for each of the number systems.

Number System	Display Capacity
Binary	16 digits
Octal	11 digits
Decimal	10 digits
Hexadecimal	8 digits

- The following are the calculation capacities for each of the number systems.

Calculation Ranges in BASE Mode
Binary Values
  Negative : $1000000000000000 \leqq x \leqq 1111111111111111$
  Positive : $0 \leqq x \leqq 111111111111111$
Octal Values
  Negative : $20000000000 \leqq x \leqq 37777777777$
  Positive : $0 \leqq x \leqq 17777777777$
Decimal Values
  Negative : $-2147483648 \leqq x \leqq -1$
  Positive : $0 \leqq x \leqq 2147483647$
Hexadecimal Values
  Negative : $80000000 \leqq x \leqq FFFFFFFF$
  Positive : $0 \leqq x \leqq 7FFFFFFF$

• To enter the BASE Mode

Highlight the **BASE** icon on the Main Menu.

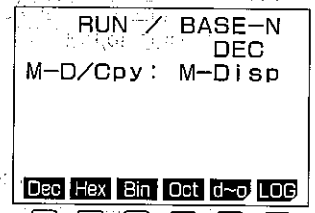
[MENU]

[▲][▼][◀][▶]

Press [EXE] or [2] to display the BASE Mode.

[EXE] (or [2])

Main BASE Mode screen



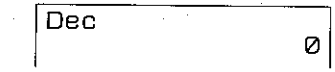
The following are the number systems that are available.

[F1](Dec) ..... decimal
[F2](Hex) ..... hexadecimal
[F3](Bin) ..... binary
[F4](Oct) ..... octal
[F5](d~o) ..... Number system specification menu
[F6](LOG) ..... Logical operation menu

• To set the default BASE Mode number system

Example **To set the default BASE Mode number system to decimal**

[F1](Dec)[EXE]

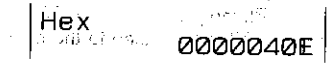


• To convert a displayed value from one number system to another

Example **To convert $1{,}038_D$ (default number system) to its hexadecimal value**

[AC][1][0][3][8][EXE]

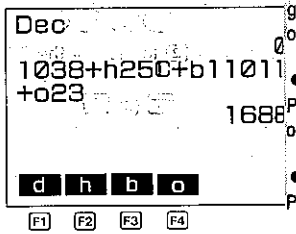
[F2](Hex)[EXE]



• To input values of mixed number systems

Example **To input $1{,}038_D + 25C_H + 11011_B + 23_O$, when the default number syste is decimal**

AC F1(Dec) EXE
1 0 3 8 + F5(d~o) F2(h)
2 5 C + F3(b) 1 1 0 1 1
+ F4(o) 2 3 EXE



The following are the types of values that can be specified in the above menu.

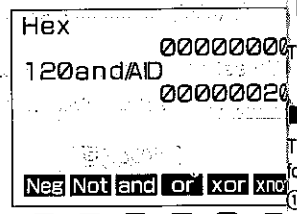
F1(d) ..... decimal value
F2(h) ..... hexadecimal value
F3(b) ..... binary value
F4(o) ..... octal value

•Press EXIT to back step to the main BASE Mode screen.

• To input logical operations

Example **To input and execute "120_{16} and AD_{16}"**

AC F2(Hex) EXE
1 2 0 F6(LOG) F3(and)
A D EXE



The following are the logical operations that can be input from the above menu.

F1(Neg) ..... negation
F2(Not) ..... NOT
F3(and) ..... AND
F4(or) ..... OR
F5(xor) ..... XOR
F6(xnor) ..... XNOR

•Press EXIT to back step to the main BASE Mode screen.

1-7 Graphic and Text Displays

The unit uses both a graphic display and a text display. The graphic display is used for graphics, while the text display is used for calculations and instructions. The contents of each type of display are stored in independent memory areas.

• To switch between the graphic display and text display

Press the G↔T key. You should also note that the key operations used to clear each type of display are different.

• To clear the graphic display

Press SHIFT F5(Cls) EXE.

• To clear the text display

Press AC.

If you press AC while in the graphic display, the calculator clears the display and automatically switches to the text display. Though the graphic display is cleared, it remains in memory, so you can return the graph to the display by pressing G↔T.

1-8 Technical Information

This section provides information on the internal workings of the unit.

■Calculation Priority Sequence

This calculator employs true algebraic logic to calculate the parts of a formula in the following order:

①Coordinate transformation
Pol (x, y), Rec (r, θ)
Differentiation/Integration
d/dx, $\int dx$
②Type A functions
With these functions, the value is entered and then the function key is pressed.
x^2, x^{-1}, $x!$, °′″, ENG symbols
③Power/root
$\wedge(x^y)$, $\sqrt[x]{\ }$
④Fractions
$a\,b/c$
⑤Abbreviated multiplication format in front of π, memory or parenthesis
2π, 5A, $3\sin x$, etc.

A313025-28

⑥ Type B functions
With these functions, the function key is pressed and then the value is entered.
$\sqrt{\ }$, $\sqrt[3]{\ }$, log, ln, e^x, 10^x, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, (−), parenthesis, (following in BASE Mode only) d, h, b, o, Neg, Not
(also Mat, Det, Trn in the MAT Mode only)

⑦ Abbreviated multiplication format in front of Type B functions
$2\sqrt{3}$, A log2, etc.

⑧ Permutation, combination
nPr, nCr

⑨ ×, ÷

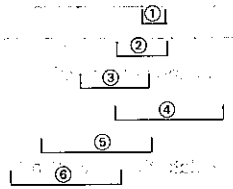
⑩ +, −

⑪ and
⑫ or, xor, xnor
] BASE Mode only

•When functions with the same priority are used in series, execution is performed fr
right to left.
$e^x\ln\sqrt{120} \rightarrow e^x\{\ln(\sqrt{120})\}$
Otherwise, execution is from left to right.

•Anything contained within parentheses receives highest priority.

Example $2+3\times(\log \sin 2\pi^2 + 6.8) = 22.07101691$ **(in the "Rad" mode)**

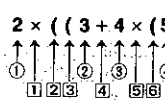


■Stacks

The unit employs memory blocks, called *stacks*, for storage of low priority values a
commands. There is a 10-level *numeric value stack*, a 26-level *command stack*, and
10-level *program subroutine stack*. If you execute a formula so complex it exceeds
amount of stack space available, an error message appears on the display (Stk ERRO
during calculations or Ne ERROR during execution of a program subroutine).

```
Stk ERROR
Bytes    26
```


Example $2\times((3+4\times(5+4)\div3)\div5)+8=$



Numeric Value Stack

①	2
②	3
③	4
④	5
⑤	4
⋮	

Command Stack

1	×
2	(
3	(
4	+
5	×
6	(
7	+

•Calculations are performed according to the priority sequence described on page 47.
Once a calculation is executed, it is cleared from the stack.

■Value Input and Output Limitations

The allowable range for both input and output values is 10 digits for the mantissa and 2 digits for the exponent. Internally, however, the unit performs calculations using 13 digits for the mantissa and 2 digits for the exponent.

Example $3\times10^5\div7-42857=$

AC 3 EXP 5 ÷ 7 EXE
3 EXP 5 ÷ 7 − 4 2 8 5 7 EXE

```
3E5÷7
          42857.14286
3E5÷7-42857
          0.14285714
```

Calculation results that are greater than 10^{10} (10 billion) or less than 10^{-2} (0.01) are automatically displayed in exponential form.

AC 3 EXP 5 ÷ 7 EXE
− 4 2 8 5 7 EXE

```
3E5÷7
          42857.14286
42857.14286-4285
7
          0.14286
```

After a calculation is complete, the calculator rounds off the mantissa to 10 digits and displays the result. The displayed result can be used in the next calculation.
Values are stored in memory with 13 digits for the mantissa and 2 digits for the exponent.

■Input Capacity

This unit has a 127-byte area for execution of calculations. Each time you press a numer key or arithmetic operation key, one byte of memory is used. In addition, the followi functions take up two bytes each:

- d/dx (
- Mat, Det, Trn (MAT Mode)
- *ROW, *ROW+, ROW+, Swap (using Matrices in Program)
- *Y, r, Xt, Yt, Sim X, Sim Y, Sim Z, Sim Coef, Ply X_1, Ply X_2, Ply Coef (VAR Mem

A calculation can consist of up to 127 bytes. Whenever you input the 121st byte of a calculation, the cursor changes from "_" to "■" on the display to let you know th you are running out of memory. If you still need to input more, you should divide yo calculation into two or more parts.

Note

- As you input numeric values or commands, they appear flush left on the displa Calculation results, on the other hand, are displayed flush right.

■Overflow and Errors

Exceeding a specified input or calculation range, or attempting an illegal input cause an error message to appear on the display. Further operation of the calculator is impos ble while an error message is displayed. The following events cause an error messag to appear on the display.

- When any result, whether intermediate or final, or any value in memory exceed $\pm 9.999999999 \times 10^{99}$ (Ma ERROR)
- When an attempt is made to perform a function calculation that exceeds the input rang (Ma ERROR) (see page 271)
- When an illegal operation is attempted during statistical calculations (Ma ERROR) For example, attempting to obtain $\bar{x}$ or $x\sigma n$ without data input.
- When the capacity of the numeric value stack or command stack is exceeded (Stk ERRO For example, entering 25 successive (, followed by 2+3×4=.
- When an attempt is made to perform a calculation using an illegal formula (Syn ERRO For example, 5××3=.
- When an illegal memory specification is made (Mem ERROR)
- When an illegal command or function argument is used (Arg ERROR)
- When an attempt is made to use an illegal dimension during matrix calculations (Di ERROR)

Notes

- Other errors can occur during program execution. See page 269 for details. Most of the calculator's keys are inoperative while an error message is displayed. Yo can resume operation using one of the two following procedures.
- Press the AC key to clear the error and return to normal operation.
- Press ◀ or ▶ to display the error (see page 29).

■Exponential Display

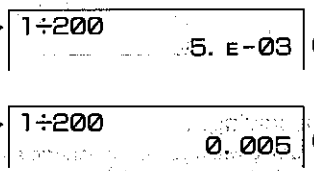
During normal calculation, the unit is capable of displaying up to 10 digits. Values that exceed this limit, however, are automatically displayed in exponential format. You can choose between 2 different types of exponential display formats.

Norm 1: $10^{-2}(0.01) > |x|, |x| \geqq 10^{10}$

Norm 2: $10^{-9}(0.000000001) > |x|, |x| \geqq 10^{10}$

You can select between Norm 1 and Norm 2 using the Display Mode (page 25). Pressing Disp displays the current mode settings.

1÷200=

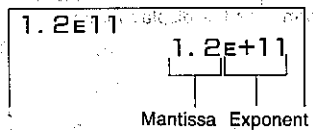


(Norm 1 display format)

(Norm 2 display format)

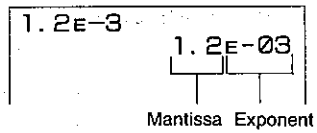
(All of the examples in this manual show calculation results using Norm 1.)

How to interpret exponential format



➡ 1.2×10^{11} ➡ 120,000,000,000

1.2E+11 indicates that the result is equivalent to 1.2×10^{11}. This means that you should move the decimal point in 1.2 eleven places to the right, since the exponent is positive. This results in the value 120,000,000,000.

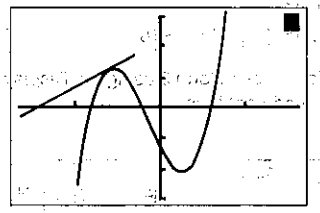


➡ 1.2×10^{-3} ➡ 0.0012

1.2E-03 indicates that the result is equivalent to 1.2×10^{-3}. This means that you should move the decimal point in 1.2 three places to the left, since the exponent is negative. This results in the value 0.0012.

■Calculation Execution Display

When the calculator is busy drawing a graph or executing a long, complex calculati or program, a black box (■) flashes in the upper right corner of the display. This bla box indicates that the calculator is performing an internal operation.



■When Errors Keep Occurring...

If you find that errors keep occurring when you try to perform an operation, use the f lowing procedure to bring the calculator back to its initial settings and try again.

(1) Press [MENU] to display the Main Menu.
(2) Use the cursor keys to highlight the COMP icon and then press [EXE].
(3) Press [SHIFT] [DRG] [F1](Deg)[EXE] to set degrees as the angular unit.
(4) Press [SHIFT] [DISP] [F3](Nrm)[EXE] to set Norm 1 as the display format.

Chapter 2

Manual Calculations

2-1 Arithmetic Calculations
2-2 Units of Angular Measurement
2-3 Trigonometric and Inverse Trigonometric Functions
2-4 Logarithmic and Exponential Functions
2-5 Hyperbolic and Inverse Hyperbolic Functions
2-6 Other Functions
2-7 Coordinate Conversion
2-8 Permutation and Combination
2-9 Fractions
2-10 Engineering Symbol Calculations
2-11 Number of Decimal Places, Number of Significant Digits, Display Format
2-12 Calculations Using Memory
2-13 BASE Mode Calculations

Chapter 2 Manual Calculations

Manual calculations are those that you input manually, as on the simplest of calculato
They are to be distinguished from programmed calculations. This chapter provides v
ious examples to help you become familiar with the manual calculation capabilities of t
unit.

2-1 Arithmetic Calculations

- Enter arithmetic calculations as they are written, from left to right.
- Use the (−) key to input the minus sign before a negative value.
- Calculations are performed internally with a 13-digit mantissa. The display is round
to a 10-digit mantissa before it is displayed.

Example	Operation	Display
$23+4.5-53=-25.5$	23 + 4.5 − 53 EXE	−25
$56\times(-12)\div(-2.5)=268.8$	56 × (−) 12 ÷ (−) 2.5 EXE	268
$12369\times7532\times74103=6.903680613\times10^{12}$ (6903680613000)	12369 × 7532 × 74103 EXE	6.903680613E+1
$(4.5\times10^{75})\times(-2.3\times10^{-79})=-1.035\times10^{-3}$ (−0.001035)	4.5 EXP 75 × (−) 2.3 EXP (−) 79 EXE	−1.035E−0 (Norm 1 display form
$(2+3)\times10^{2}=500$	(2 + 3) × 1 EXP 2 EXE	50
• (2 + 3) EXP 2 does not produce the correct result. Be sure to enter this calculation as shown.		
$(1\times10^{5})\div7=14285.71429$	1 EXP 5 ÷ 7 EXE	14285.7142
$(1\times10^{5})\div7-14285=0.71428571$	1 EXP 5 ÷ 7 − 14285 EXE	0.7142857

- For mixed arithmetic calculations, multiplication and division are given priority over addition and subtraction.

Example	Operation	Display
$3+5\times6=33$	3 + 5 × 6 EXE	33.
$7\times8-4\times5=36$	7 × 8 − 4 × 5 EXE	36.
$1+2-3\times4\div5+6=6.6$	1 + 2 − 3 × 4 ÷ 5 + 6 EXE	6.6

■ Calculations Using Parentheses

Example	Operation	Display
$100-(2+3)\times4=80$	100 − (2 + 3) × 4 EXE	80.
$2+3\times(4+5)=29$	2 + 3 × (4 + 5 EXE	29.
• The final closed parentheses (immediately before operation of the EXE key) may be omitted, no matter how many are required.		
$(7-2)\times(8+5)=65$	(7 − 2) (8 + 5 EXE	65.
• A multiplication sign immediately before an open parenthesis may be omitted.		
$10-\{2+7\times(3+6)\}=-55$	10 − (2 + 7 (3 + 6 EXE	−55.
• In this manual, the multiplication sign is always shown.		
$\frac{2\times3+4}{5}=(2\times3+4)\div5=2$	(2 × 3 + 4) ÷ 5 EXE	2.
$\frac{5\times6+6\times8}{15\times4+12\times3}=0.8125$	(5 × 6 + 6 × 8) ÷ (15 × 4 + 12 × 3) EXE	0.8125
$(1.2\times10^{19})-\{(2.5\times10^{20})\times\frac{3}{100}\}=4.5\times10^{18}$	1.2 EXP 19 − (2.5 EXP 20 × 3 ÷ 100) EXE	4.5E+18
$\frac{6}{4\times5}=0.3$	6 ÷ (4 × 5) EXE	0.3
• The above is identical to 6 ÷ 4 ÷ 5 EXE.		

2-2 Units of Angular Measurement

- See page 23 for full details on specifying the unit of angular measurement.
- Once you specify a unit of angular measurement, it remains in effect until you specify a different one. The specification is retained even if you switch power off.
- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
Result displayed in degrees.		
To convert 4.25 rad to degrees.	SHIFT DRG F1 (Deg) EXE 4.25 F5 (r) EXE	243.507062
47.3° + 82.5rad = 4774.20181°	47.3 + 82.5 F5 (r) EXE	4774.2018

2-3 Trigonometric and Inverse Trigonometric Functions

- Be sure to set the unit of angular measurement before performing trigonometric function and inverse trigonometric function calculations.
- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
sin 63°52′41″ = 0.897859012	SHIFT DRG F1 (Deg) EXE sin 63 SHIFT MATH F4 (DMS) F1 (° ′ ″) 52 F1 (° ′ ″) 41 F1 (° ′ ″) EXE	0.897859012
$\cos\left(\frac{\pi}{3}\text{ rad}\right) = 0.5$	SHIFT DRG F2 (Rad) EXE cos (SHIFT π ÷ 3) EXE	0.5
tan(−35gra) = −0.6128007881	SHIFT DRG F3 (Gra) EXE tan (−) 35 EXE	−0.6128007881
2·sin 45° × cos 65° = 0.5976724775	SHIFT DRG F1 (Deg) EXE 2 × sin 45 × cos 65 EXE (× can be omitted)	0.5976724775
$\cot 30° = \frac{1}{\tan 30°}$ = 1.732050808	1 ÷ tan 30 EXE	1.732050808

2-4 Logarithmic and Exponential Functions

- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
log 1.23 ($\log_{10}1.23$) = 8.990511144 × 10^{-2}	log 1.23 EXE	0.08990511144
ln90 (log90) = 4.49980967	ln 90 EXE	4.49980967
$10^{1.23}$ = 16.98243652	SHIFT 10^x 1.23 EXE (To obtain the antilogarithm of common logarithm 1.23)	16.98243652
$e^{4.5}$ = 90.0171313	SHIFT e^x 4.5 EXE (To obtain the antilogarithm of natural logarithm 4.5)	90.0171313
$10^4 \cdot e^{-4} + 1.2 \cdot 10^{2.3}$ = 422.5878667	SHIFT 10^x 4 × SHIFT e^x (−) 4 + 1.2 × SHIFT 10^x 2.3 EXE	422.5878667
$(-3)^4 = (-3)\times(-3)\times(-3)\times(-3) = 81$	((−) 3) ^ 4 EXE	81.
$-3^4 = -(3\times3\times3\times3) = -81$	(−) 3 ^ 4 EXE	−81.
$5.6^{2.3}$ = 52.58143837	5.6 ^ 2.3 EXE	52.58143837
$\sqrt[7]{123}$ $(= 123^{\frac{1}{7}})$ = 1.988647795	7 SHIFT $\sqrt{\ }$ 123 EXE	1.988647795

2-5 Hyperbolic and Inverse Hyperbolic Functions

•The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
$\sinh 3.6 = 18.28545536$	SHIFT MATH F1(HYP) F1(snh) 3.6 EXE	18.28545536
$\cosh^{-1}\left(\frac{20}{15}\right) = 0.7953654612$	SHIFT MATH F1(HYP) F5(csh^{-1}) (20 ÷ 15) EXE	0.795365461
Determine the value of x when $\tanh 4x = 0.88$ $x = \frac{\tanh^{-1}0.88}{4}$ $= 0.3439419141$	SHIFT MATH F1(HYP) F6(tnh^{-1}) 0.88 ÷ 4 EXE	0.343941914

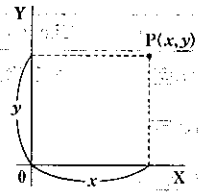
2-6 Other Functions

•The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
$\sqrt{2}+\sqrt{5} = 3.65028154$	SHIFT √ 2 + SHIFT √ 5 EXE	3.65028154
$(-3)^2 = (-3)\times(-3) = 9$	((−) 3) x^2 EXE	9.
$-3^2 = -(3\times3) = -9$	(−) 3 x^2 EXE	−9.
$2^2+3^2+4^2+5^2 = 54$	2 x^2 + 3 x^2 + 4 x^2 + 5 x^2 EXE	54.
$\frac{1}{\frac{1}{3}-\frac{1}{4}} = 12$	(3 SHIFT x^{-1} − 4 SHIFT x^{-1}) SHIFT x^{-1} EXE	12.
$8!\,(= 1\times2\times3\times\cdots\times8) = 40320$	8 SHIFT MATH F2(PRB) F1($x!$) EXE	40320.
$\sqrt[3]{-27} = -3$	SHIFT $\sqrt[3]{}$ (−) 27 EXE	−3.
$\frac{1}{2!}+\frac{1}{4!}+\frac{1}{6!}+\frac{1}{8!} = 0.5430803571$	2 SHIFT MATH F2(PRB) F1($x!$) SHIFT x^{-1} + 4 F1($x!$) SHIFT x^{-1} + 6 F1($x!$) SHIFT x^{-1} + 8 F1($x!$) SHIFT x^{-1} EXE	0.5430803571
What is the absolute value of the common logarithm of $\frac{3}{4}$? $\left\lvert \log\frac{3}{4} \right\rvert = 0.1249387366$	SHIFT MATH F3(NUM) F1(Abs) log (3 ÷ 4) EXE	0.1249387366
What is the integer part of −3.5?	SHIFT MATH F3(NUM) F2(Int) (−) 3.5 EXE	−3.
What is the decimal part of −3.5?	SHIFT MATH F3(NUM) F3(Frc) (−) 3.5 EXE	−0.5
What is the nearest integer not exceeding −3.5?	SHIFT MATH F3(NUM) F5(Intg) (−) 3.5 EXE	−4.

2-7 Coordinate Conversion

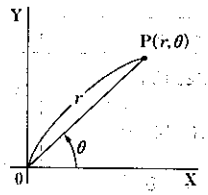
•Rectangular Coordinates



Pol

Rec

•Polar Coordinates



•Calculation results are stored in value memories I and J.

	I	J
Pol	r	θ
Rec	x	y

•With polar coordinates, θ can be calculated within a range of $-180° < \theta \leqq 180°$ (radian and grads have same range).

•The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
To calculate r and $\theta°$ when $x=14$ and $y=20.7$.	SHIFT DRG F1 (Deg) EXE	
	SHIFT MATH F5 (COR) F1 (Pol)	
	14 SHIFT) 20.7) EXE	24.98979792 (r)
	(Continuing) ALPHA J EXE	55.92839019
	SHIFT MATH F4 (DMS) F2 (° ' ")	55°55'42.2" (θ)
To calculate x and y when $r=4.5$ and $\theta=\frac{2}{3}\pi$ rad.	SHIFT DRG F2 (Rad) EXE	
	SHIFT MATH F5 (COR) F2 (Rec)	
	4.5 SHIFT) (2 ÷ 3 ×	
	SHIFT π)) EXE	−2.25 (x)
	(Continuing) ALPHA J EXE	3.897114317 (y)

2-8 Permutation and Combination

•Permutation

$${}_nPr=\frac{n!}{(n-r)!}$$

•Combination

$${}_nCr=\frac{n!}{r!(n-r)!}$$

•The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
To calculate the possible number of different arrangements using 4 items selected from among of 10 items. ${}_{10}P_4=5040$	10 SHIFT MATH F2 (PRB) F2 ($_nPr$) 4 EXE	5040.
To calculate the possible number of different combinations of 4 items that can be selected from among 10 items. ${}_{10}C_4=210$	10 SHIFT MATH F2 (PRB) F3 ($_nCr$) 4 EXE	210.

2-9 Fractions

- Fractional values are displayed with the integer first, followed by the numerator and then the denominator.
- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
$\frac{2}{5}+3\frac{1}{4}=3\frac{13}{20}$	2 a⅞ 5 + 3 a⅞ 1 a⅞ 4 EXE	3⌟13⌟20
$=3.65$	(Conversion to decimal) a⅞	3.65
• Fractions can be converted to decimal values and vice versa.		
$3\frac{456}{78}=8\frac{11}{13}$ (Reduced)	3 a⅞ 456 a⅞ 78 EXE	8⌟11⌟13
	(Continuing) SHIFT d/c	115⌟13
• Fractions and improper fractions that can be reduced become reduced fractions when you press a calculation command key. Press SHIFT d/c to convert the value to an improper fraction.		
$\frac{1}{2578}+\frac{1}{4572}$		
$=6.066202547\times10^{-4}$	1 a⅞ 2578 + 1 a⅞ 4572 EXE	6.066202547E-04
		(Norm 1 display format)
• When the total number of characters, including integer, numerator, denominator and delimiter marks exceeds 10, the input fraction is automatically displayed in decimal format.		
$\frac{1}{2}\times0.5=0.25$	1 a⅞ 2 × . 5 EXE	0.25
• Calculations containing both fractions and decimals are calculated in decimal format.		
$\frac{1}{\frac{1}{3}+\frac{1}{4}}=1\frac{5}{7}$	1 a⅞ (1 a⅞ 3 + 1 a⅞ 4) EXE	1⌟5⌟7
• You can include fractions within the numerator or denominator of a fraction by putting the numerator or denominator in parentheses.		

2-10 Engineering Symbol Calculations

Input engineering symbols using the Engineering Symbol Menu from the MATH Menu, as described on page 35.

Perform the following operation to change a displayed value to a corresponding Engineering Mode.

SHIFT DISP → Fix Sci Nrm Eng (F4)

F4(Eng) EXE → Eng 0.

Each time you perform this operation, the display changes between Engineering Mode and standard (non-engineering) format.

- The unit automatically selects the engineering symbol that makes the numeric value fall within the range of 1 to 999.
- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
	SHIFT DISP F4(Eng) EXE	
999k (kilo) + 25k (kilo)	999 SHIFT MATH F6(SYM) F6(▽)	
= 1.024M (mega)	F1(k) + 25 F1(k) EXE	1.024M
	SHIFT DISP F4(Eng) EXE	1024000.
	SHIFT DISP F4(Eng) EXE	
9 ÷ 10 = 0.9 = 900m (milli)	9 ÷ 10 EXE	900.m
(Converts the displayed value to the next higher engineering unit, by shifting the decimal point three places to the right.)		
	F6(←ENG)	0.9
	F6(←ENG)	0.0009k
(Converts the displayed value to the next lower engineering unit, by shifting the decimal point three places to the left.)		
	F5(ENG)	0.9
	F5(ENG)	900.m
	F5(ENG)	900000.μ
	F6(←ENG)	900.m

2-11 Number of Decimal Places, Number of Significant Digits, Display Format

•See page 23 for details on specifying the number of decimal places.
•See page 24 for details on specifying the number of significant digits.
•See page 25 for details on specifying the display format.

Example	Operation	Display
100 ÷ 6 = 16.66666666...	100 ÷ 6 EXE	16.6666666
	(4 decimal places) SHIFT DISP F1 (Fix) 4 EXE	16.666
	(Cancels specification) F3 (Nrm) EXE	16.6666666
	(5 significant digits) F2 (Sci) 5 EXE	1.6667E+01
	(Cancels specification) F3 (Nrm) EXE	16.6666666
	•Displayed values are rounded off to the place you specify.	
200 ÷ 7 × 14 = 400	200 ÷ 7 × 14 EXE	400
	(3 decimal places) SHIFT DISP F1 (Fix) 3 EXE	400.000
	(Calculation continues using display capacity of 10 digits)	
	200 ÷ 7 EXE	28.57
	×	28.57142857 ×
	14 EXE	400.000
	If the same calculation is performed using the specified number of digits:	
	200 ÷ 7 EXE	28.57
	(The value stored internally is cut off to the number of decimal places you specify.)	
	SHIFT MATH F3 (NUM) F4 (Rnd) EXE	28.57
	×	28.571 × _
	14 EXE	399.99
	(Cancels specification) SHIFT DISP F3 (Nrm) EXE	399.99

2-12 Calculations Using Memory

•See page 36 for details on value memories.

Example	Operation	Display
	193.2 → ALPHA A EXE	193.2
193.2 ÷ 23 = 8.4	ALPHA A ÷ 23 EXE	8.4
193.2 ÷ 28 = 6.9	ALPHA A ÷ 28 EXE	6.9
193.2 ÷ 42 = 4.6	ALPHA A ÷ 42 EXE	4.6
$\frac{9\times6+3}{(7-2)\times8}$ = 1.425	9 × 6 + 3 → ALPHA B EXE	57.
	(7 − 2) × 8 → ALPHA C EXE	40.
	ALPHA B ÷ ALPHA C EXE	1.425
	•The same result can be produced by entering (9 × 6 + 3) ÷ ((7 − 2) × 8) EXE.	
23 + 9 = 32	23 + 9 → ALPHA B EXE	32.
53 − 6 = 47	53 − 6 EXE	47.
−) 45 × 2 = 90	ALPHA B + SHIFT Ans → ALPHA B EXE	79.
99 ÷ 3 = 33	45 × 2 EXE	90.
Total 22	ALPHA B − SHIFT Ans → ALPHA B EXE	−11.
	99 ÷ 3 EXE	33.
	ALPHA B + SHIFT Ans → ALPHA B EXE	22.
12 × (2.3 + 3.4) − 5 = 63.4	2.3 + 3.4 → ALPHA G EXE	5.7
30 × (2.3 + 3.4 + 4.5) − 15	12 × ALPHA G − 5 EXE	63.4
× 4.5 = 238.5	4.5 → ALPHA H EXE	4.5
	30 × (ALPHA G + ALPHA H	
	) − 15 ALPHA H EXE	238.5
	•Multiplication signs (×) immediately before memory names can be omitted.	

2-13 BASE Mode Calculations

■Conversions

Example	Operation	Display
To convert $2A_{16}$ and 274_8 to decimal	[MENU](BASE)[EXE]	
	[AC][F1](Dec)[EXE]	0
	[F5](d~o)[F2](h)**2A**[EXE]	42
	[F4](o)**274**[EXE]	188
To convert 123_{10} and 1010_2 to hexadecimal	[AC][EXIT][F2](Hex)[EXE]	00000000
	[F5](d~o)[F1](d)**123**[EXE]	0000007B
	[F3](b)**1010**[EXE]	0000000A

■Negative Values

Example	Operation	Display
Negative of 110010_2	[MENU](BASE)[EXE]	
	[AC][F3](Bin)[EXE]	0000000000000000
	[F6](LOG)[F1](Neg)**110010**[EXE]	1111111111001110

■Arithmetic Operations

Example	Operation	Display
	[MENU](BASE)[EXE]	
	[AC][F2](Hex)[EXE]	00000000
$123_8 \times ABC_{16} = 37AF4_{16}$	[F5](d~o)[F4](o)**123**[×]**ABC**[EXE]	00037AF4
$= 228084_{10}$	[EXIT][F1](Dec)[EXE]	228084
$7654_8 \div 12_{10} = 334.3333333_{10}$	[AC][F1](Dec)[EXE]	0
$= 516_8$	[F5](d~o)[F4](o)**7654**[÷]**12**[EXE]	334
	[EXIT][F4](Oct)[EXE]	00000000516

•Fractional parts are cut off before results are displayed.

■Logical Operations

•See page 46 for details on the logical operations menu.

Example	Operation	Display
	[MENU](BASE)[EXE]	
	[AC][F2](Hex)[EXE]	00000000
19_{16} AND $1A_{16} = 18_{16}$	**19**[F6](LOG)[F3](and)**1A**[EXE]	00000018
	[AC][EXIT][F3](Bin)[EXE]	0000000000000000
1110_2 AND $36_8 = 1110_2$	**1110**[F6](LOG)[F3](and)[EXIT]	
	[F5](d~o)[F4](o)**36**[EXE]	0000000000001110
	[AC][EXIT][F4](Oct)[EXE]	00000000000
23_8 OR $61_8 = 63_8$	**23**[F6](LOG)[F4](or)**61**[EXE]	00000000063
	[AC][EXIT][F2](Hex)[EXE]	00000000
120_{16} OR $1101_2 = 12D_{16}$	**120**[F6](LOG)[F4](or)[EXIT]	
	[F5](d~o)[F3](b)**1101**[EXE]	0000012D
	[AC][EXIT][F3](Bin)[EXE]	0000000000000000
1010_2 AND (A_{16} OR 7_{16}) = 1010_2	**1010**[F6](LOG)[F3](and)[(][EXIT][F5](d~o)[F2](h)**A**[EXIT][F6](LOG)[F4](or)[EXIT][F5](d~o)[F2](h)**7**[)][EXE]	0000000000001010
	[AC][EXIT][F2](Hex)[EXE]	00000000
5_{16} XOR $3_{16} = 6_{16}$	**5**[F6](LOG)[F5](xor)**3**[EXE]	00000006
	[AC][EXIT][F2](Hex)[EXE]	00000000
$2A_{16}$ XNOR $5D_{16}$ = $FFFFFF88_{16}$	**2A**[F6](LOG)[F6](xnor)**5D**[EXE]	FFFFFF88
	[AC][EXIT][F4](Oct)[EXE]	00000000000
Negation of 1234_8	[F6](LOG)[F2](Not)**1234**[EXE]	37777776543
	[AC][EXIT][F2](Hex)[EXE]	00000000
Negation of $2FFFED_{16}$	[F6](LOG)[F2](Not)	
	2FFFED[EXE]	FFFD00012

Chapter 3

Differential and Integration Calculations

3-1 How the Unit Calculates Differentials
3-2 How the Unit Calculates Integrations

Chapter 3 Differential and Integration Calculations

This chapter provides procedures for performing differential and integration calculations.

3-1 How the Unit Calculates Differentials

The following is the input format for differentials:

[SHIFT] [d/dx] $f(x)$ [SHIFT] [,] a [SHIFT] [,] Δx [)]

Δx: Increase/decrease of x

a: Point for which you want to determine the derivative

$$d/dx(f(x),\ a,\ \Delta x) \rightarrow \frac{d}{dx}f(a)$$

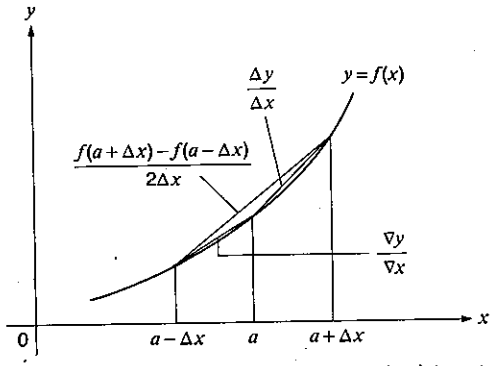
The differentiation for this type of calculation is defined as:

$$f'(a)=\lim_{\Delta x\to 0}\frac{f(a+\Delta x)-f(a)}{\Delta x}$$

In this definition, *infinitesimal* is replaced by a *sufficiently small* Δx, with the value in the neighborhood of $f'(a)$ calculated as:

$$f'(a)\fallingdotseq\frac{f(a+\Delta x)-f(a)}{\Delta x}$$

In order to provide the best precision possible, this unit employs central difference to perform differential calculations. The following illustrates central difference.



The slopes of point a and point $a+\Delta x$, and of point a and point $a-\Delta x$ in function $y=f(x)$ are as follows:

$$\frac{f(a+\Delta x)-f(a)}{\Delta x}=\frac{\Delta y}{\Delta x},\quad \frac{f(a)-f(a-\Delta x)}{\Delta x}=\frac{\nabla y}{\nabla x}$$

In the above, $\Delta y/\Delta x$ is called the forward difference, while $\nabla y/\nabla x$ is the backward difference. To calculate derivatives, the unit takes the average between the value of $\Delta y/\Delta x$ and $\nabla y/\nabla x$, thereby providing higher precision for derivatives.

This average, which is called the *central difference*, is expressed as:

$$f'(a)=\frac{1}{2}\left(\frac{f(a+\Delta x)-f(a)}{\Delta x}+\frac{f(a)-f(a-\Delta x)}{\Delta x}\right)$$
$$=\frac{f(a+\Delta x)-f(a-\Delta x)}{2\Delta x}$$

■To Perform a Differential Calculation

Example **To determine the derivative at point $x=3$ for the function $y=x^3+4x^2+x-6$, when the increase/decrease of x is defined as $\Delta x=1\text{E}-5$.**

Input the function $f(x)$.

[AC] [SHIFT] [d/dx] [X,θ,T] [^] [3] [+] [4] [X,θ,T] [x^2] [+] [X,θ,T] [−] [6] [SHIFT] [,]

```
d/dx(X^3+4X²+X−6
,_
```

Input point $x=a$ for which you want to determine the derivative.

[3] [SHIFT] [,]

```
d/dx(X^3+4X²+X−6
,3,_
```

Input Δx, which is the increase/decrease of x.

[1] [EXP] [(−)] [5] [)]

```
d/dx(X^3+4X²+X−6
,3,1E−5)_
```

[EXE]

```
d/dx(X^3+4X²+X−6
,3,1E−5)
                52.
```

- Note that only x can be used an expression in the function $f(x)$. All other variables (alpha characters, r, θ) are regarded as constants, and the values stored for them in value memory are applied for the calculation.
- Input of Δx for the increase/decrease of x can be skipped. When you do, the unit automatically uses a value for Δx that is appropriate for the value of $x=a$, which you specified as the point for which you wanted to determine the derivative.
- The precision of the above operation is generally ±1 at the least significant digit.

■Applications of Differential Calculations

•Differentials can be added, subtracted, multiplied and divided with each other.

Example $\frac{d}{dx}f(a)=f'(a)$, $\frac{d}{dx}g(a)=g'(a)$

Therefore:

$f'(a)+g'(a)$, $f'(a)\times g'(a)$

•Differential results can be used in addition, subtraction, multiplication, and division, and in functions.

Example $2\times f'(a)$, $\log(f'(a))$

•Functions can be used in any of the term ($f(x)$, a, Δx) of a differential.

Example $\frac{d}{dx}(\sin x+\cos x,\ \sin 0.5)$

•You cannot use a differential as the term of an integral or another differential.

Important

•Pressing [AC] during calculation of a differential (while the cursor is not shown on the display) interrupts the calculation. After interrupting a calculation, you can use ◀ and ▶ to recall the differential formula. Pressing [EXE] executes the displayed formula again.
•Always perform trigonometric integrations using radians (Rad Mode) as the unit of angular measurement (page 23).
•Differential calculations use value memories F through H for storage, deleting any contents that were previously stored. This also means that you cannot use these value memories during differential calculations.

Value Memory	F	G	H
Data Stored	a	Δx	$df(a)/dx$

In addition to the above, the value for derivative a is stored in value memory X.

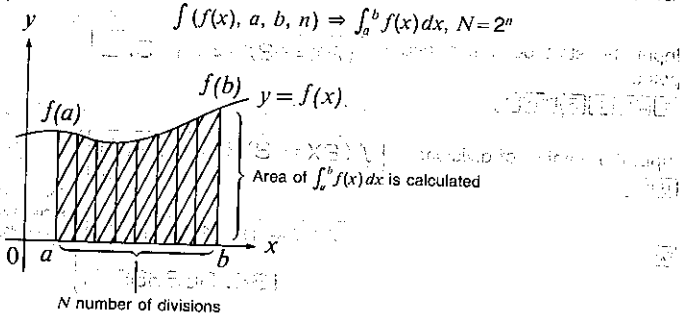
3-2 How the Unit Calculates Integrations

The following is the input format for integrations:

[SHIFT] [∫dx] $f(x)$ [SHIFT] [)] a [SHIFT] [)] b [SHIFT] [)] n [)]

- n: Number of Divisions (value for n in $N=2^n$, n is an integer from 1 through 9)
- b: End Point
- a: Start Point

$\int(f(x),\ a,\ b,\ n) \Rightarrow \int_a^b f(x)dx,\ N=2^n$



Integration calculations are performed by applying Simpson's Rule for the $f(x)$ function you input. This method requires that the number divisions be defined as $N=2^n$, where the value of n is an integer in the range of 1 through 9. If you do not specify a value for n, the calculator automatically assigns a value in accordance with the integration being performed.

As shown in the illustration above, integration calculations are performed by calculating integral values from a through b for the function $y=f(x)$ where $a\leqq x\leqq b$, and $f(x)\geqq 0$*. This in effect calculates the surface area of the shaded area in the illustration.

*If $f(x)<0$ where $a\leqq x\leqq b$, the surface area calculation produces negative values (surface area × −1).

Also note that the calculator uses the following value memories to store data during integration calculations.

Value Memory	K	L	M	N
Data Stored	a	b	$N=2^n$	$\int_a^b f(x)dx$

■To Perform an Integration Calculation

Example To perform the integration calculation for the function $\int_1^5 (2x^2+3x+4)\,dx$

Input the function $f(x)$.
AC SHIFT $\int dx$ 2 X,θ,T x^2 + 3
X,θ,T + 4 SHIFT)

$\int(2X^2+3X+4, \_$

Input the start point and end point.
1 SHIFT , 5 SHIFT)

$\int(2X^2+3X+4, 1, 5, \_$

Input the number of divisions.
6)

$\int(2X^2+3X+4, 1, 5, 6)\_$

EXE

$\int(2X^2+3X+4, 1, 5, 6)$
134.6666667

The result takes a few seconds to appear on the display.

You can confirm the parameters of this calculation by recalling the values stored in the value memories.

ALPHA K EXE → K 1. (a)

ALPHA L EXE → L 5. (b)

ALPHA M EXE → M 64. (N)

ALPHA N EXE → N 134.6666667

•$f(x)$ can use the X value memory name only. If you use any other value memory name, it is regarded as a constant and the corresponding memory contents are applied.

■Application of Integration Calculation

•Integrals can be used in addition, subtraction, multiplication and division.

Example $\int_a^b f(x)\,dx + \int_c^d g(x)\,dx$

•Integration results can be used in addition, subtraction, multiplication and division, in functions.

Example $2 \times \int_a^b f(x)\,dx$,
$\log\left(\int_a^b f(x)\,dx\right)$

•Functions can be used in any of the terms ($f(x)$, a, b, n) of an integral.

Example $\int_{\sin 0.5}^{\cos 0.5} (\sin x + \cos x)\,dx$
$= \int (\sin x + \cos x, \sin 0.5, \cos 0.5, 5)$

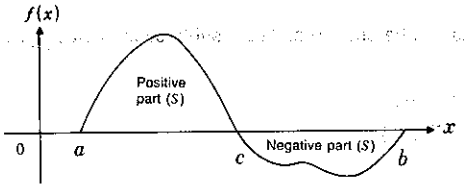
•You cannot use an integral as the term of a differential or another integral.

Important

•Pressing AC during calculation of an integral (while the cursor is not shown on the display) interrupts the calculation. After interrupting a calculation, you can use ◀ and ▶ to recall the integral formula. Pressing EXE executes the displayed formula again.
•Always perform trigonometric integrations using radians (Rad Mode) as the unit of angular measurement (see page 23).
•Integration calculations use value memories K through N for storage, deleting any contents that may be already stored. This also means that you cannot use these value memories during integration calculations.
In addition to the above, the value that represents division beginning point a is stored in value memory X following completion of the integration calculation.
•This unit utilizes Simpson's rule for integration calculation. As the number of significant digits is increased, extended calculation time is required. In some cases, calculation results may be erroneous even after considerable time expires in calculation. In particular, when significant digits are less than 1, an ERROR (Ma ERROR) sometimes occurs.
•Integration involving certain types of functions or ranges can result in relatively large errors being generated in the values produced.

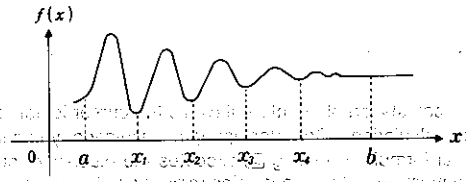
•Note the following points to ensure correct integration values.

(1) When cyclical functions for integration values become positive or negative for different divisions, perform the calculation for single cycles, or divide between negative and positive, and then add the results together.



$$\int_a^b f(x)\,dx = \underbrace{\int_a^c f(x)\,dx}_{\text{Positive part } (S)} + \underbrace{\left(-\int_c^b f(x)\,dx\right)}_{\text{Negative part } (S)}$$

(2) When minute fluctuations in integration divisions produce large fluctuations in integration values, calculate the integration divisions separately (divide the large fluctuation areas into smaller divisions), and then add the results together.



$$\int_a^b f(x)\,dx = \int_a^{x1} f(x)\,dx + \int_{x1}^{x2} f(x)\,dx + \cdots\cdots + \int_{x4}^{b} f(x)\,dx$$

Chapter 4

Statistical Calculations

4-1 Single-Variable Statistical Calculations
4-2 Paired-Variable Statistical Calculations
4-3 Things to Remember during Statistical Calculations
4-4 Examples of Statistical Calculations

Chapter 4 Statistical Calculations

There are two types of statistical calculations: *single-variable statistical calculations* performed using standard deviation, and *paired-variable statistical calculations* performed using regression.
Regression calculations can be performed using linear regression, logarithmic regression, exponential regression and power regression.
No matter what type of statistical calculations you decide to perform, you can tell the unit to either store the statistical data or not to store the data. Choosing storage of data causes the data you input to be stored in special statistical data memory. Choosing non-storage of data causes the data you input to be processed and discarded as soon as you input it. If you choose to store the data, be sure to use the following operation to clear memory contents before beginning calculations.

4-1 Single-Variable Statistical Calculations

You should use the Standard Deviation Mode to perform single-variable statistical calculations. In this mode, you can calculate the population standard deviation, the sample standard deviation, the mean, the sum of squares of the data, the sum of the data, and the number of data items.

■To Enter the Standard Deviation Mode without Data Storage

Highlight the **SD** icon on the Main Menu.

MENU

▲▼◀▶

Press EXE or 3 to display the Standard Deviation (SD) Mode.

EXE (or 3)

The first line of the SD Mode Set Up Display should show "S-data : NON-". If it shows "S-data : STO" you have to change the set up using the procedure described on page 20.

```
   RUN / SD
S-data  : NON-
S-graph : NON-
G-type  : REC/CON
angle   : Deg
display : Nrml
M-D/Cpy : M-Disp
DT CL ; DEV Σ PQR
```

F1 F2 F3 F4 F5 F6

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

F1(DT) ..... Inputs data
F2(CL) ..... Clears data
F3(;) ..... Used to input the number of data items
F4(DEV) ..... Statistical/representative menu
F5(Σ) ..... Sum data menu
F6(PQR) ..... Probability distribution menu

The unit uses the following value memories to store values. Do not use these memories for storage if you plan to perform statistical operations.

Value Memory	U	V	W
Statistical Data	Σx^2	Σx	n

•When drawing a graph for single-variable statistical data, STAT GRAPH must be set to the DRAW Mode (page 20).

•To input data

Example 1 **To input the data 10, 20, 30**

SHIFT CLR F2(Scl) EXE

10F1(DT)20F1(DT)30F1(DT)

Example 2 **To input the data 10, 20, 20, 30**

10F1(DT)20F1(DT)F1(DT)30F1(DT)

Note that simply pressing F1(DT) inputs the previously entered data.

Example 3 **To input the data 10, 20, 20, 20, 20, 20, 30**

10F1(DT)20F3(;)6F1(DT)30F1(DT)

Note that you can input multiple data items by entering the data, pressing F3(;), and then entering the number of data items.

•To delete data

Example 1 **Data input sequence: 40F1(DT)20F1(DT)30F1(DT)50F1(DT)**

To delete the 50F1(DT) (last data item entered), press F2(CL).

Example 2 **Data input sequence: 40F1(DT)20F1(DT)30F1(DT)50F1(DT)**

To delete the 20F1(DT), enter 20F2(CL).

Example 3 **Data input sequence: 30F1(DT)50F1(DT)120F3(;)**

To delete the 120F3(;), press AC.

Example 4 **Data input sequence: 30F1(DT)50F1(DT)120F3(;)31**

To delete the 120F3(;)31, press AC.

Example 5 **Data input sequence: 30F1(DT)50F1(DT)120F3(;)31F1(DT)**

To delete the 120F3(;)31F1(DT) (last item entered), press F2(CL).

Example 6 **Data input sequence: 50F1(DT)120F3(;)31F1(DT)30F1(DT)**

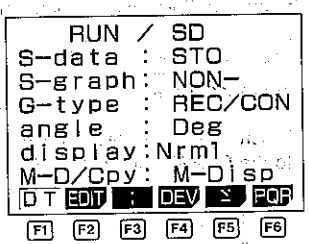
To delete the 120F3(;)31F1(DT), enter 120F3(;)31F2(CL).

A313025-28

■ To Enter the Standard Deviation Mode with Data Storage

[MENU](SD)[EXE] (or [3])

The first line of the SD Mode Set Up Display should show "S-data : STO". If it shows "S-data : NON-" you have to change the set up using the procedure described on page 20.



The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

- [F1](DT) ..... Inputs data
- [F2](EDIT) ..... Edit function menu
- [F3](;) ..... Used to input the number of data items
- [F4](DEV) ..... Statistical/representative menu
- [F5](Σ) ..... Sum data menu
- [F6](PQR) ..... Probability distribution menu

- Σx^2, Σx, and n data are stored in their own memory area, and so they do not use value memories.
- See pages 91 and 154 for the formulas used to calculate standard deviation, mean, and probability distribution.
- The maximum value is the largest value input for X, while the minimum value is the smallest value input for X.
- The median is the middle value of the distribution. If any data item has a negative value, or if it is greater than 10^{10}, or if the data includes a data item of 0, an Ma ERROR occurs.

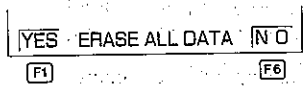
• To input data

Example 1 **To input the data 10, 20, 30**

Before actually beginning data input, use the following sequence to delete any data that may already be stored inside the special statistical data memory.

[F2](EDIT)

[F3](ERS)



[F1](YES)

10[F1](DT)20[F1](DT)30[F1](DT)

Example 2 **To input the data 10, 20, 20, 30**
10[F1](DT)20[F1](DT)[F1](DT)30[F1](DT)

Note that simply pressing [F1](DT) inputs the previously entered data.

Example 3 **To input the data 10, 20, 20, 20, 20, 20, 20, 30**
10[F1](DT)20[F3](;)6[F1](DT)30[F1](DT)

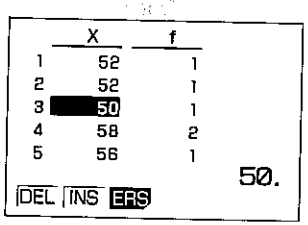
Note that you can input multiple data items by entering the data, pressing [F3](;), and then entering the number of data items.

• To edit data items stored in memory

Example **To change 50 to 54**

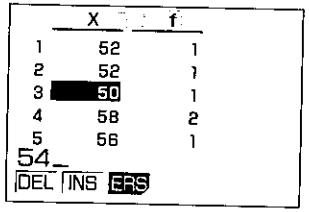
From the function menu at the bottom of the SD Mode set up display, press [F2](EDIT) to start the editing operation.

[F2](EDIT)

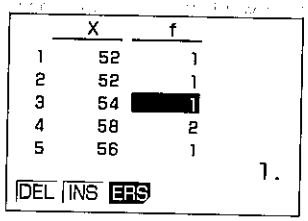


[▼][▼]

[5][4]



[EXE]



After you finish editing the data, press [EXIT] and then [F6](CAL) (see page 91).

[EXIT]

[F6](CAL)

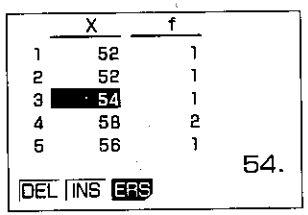
• To delete specific data items stored in memory

Example **To delete 54**

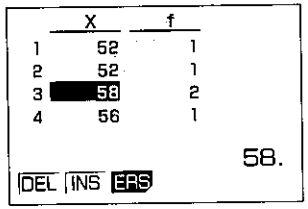
From the function menu at the bottom of the SD Mode set up display, press [F2](EDIT) to start the editing operation.

[F2](EDIT)

[⏷⏷]



[F1](DEL)



After you finish deleting the data, press [EXIT] and then [F6](CAL) (see page 91).

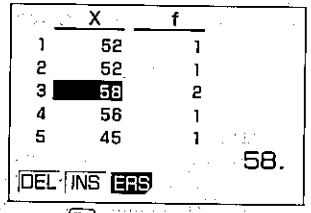
• To insert data items into data stored in memory

Example **To insert 0 between 52 and 58**

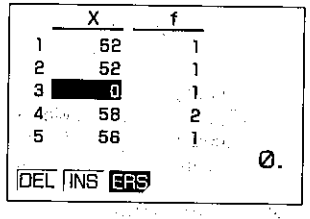
From the function menu at the bottom of the SD Mode set up display, press [F2](EDIT) to start the editing operation.

[F2](EDIT)

[⏷⏷]



[F2](INS)



After you finish inserting the data, press [EXIT] and then [F6](CAL) (see page 91).

■Performing Single-Variable Calculations

After inputting the data, select the type of operation you want from the function menu at the bottom of the SD Mode set up display. Press one of the following function keys to display a menu of available operations.

[F4](DEV) ..... Statistical/representative menu
[F5](Σ) ..... Sum data menu
[F6](PQR) ..... Probability distribution menu

Each of these menus is described in detail below.

Without data storage (S-data : NON-)

• Statistical/Representative Menu

[F4](DEV)

[F1]($\bar{x}$) ..... Mean of x-data
[F2]($x\sigma n$) ..... Population standard deviation of x-data
[F3]($x\sigma n-1$) ..... Sample standard deviation of x-data
[F4](Mod) ..... Mode value for input data

With data storage (S-data : STO)

• Statistical/Representative Menu

[F4](DEV)

[F1]($\bar{x}$) ..... Mean of x-data
[F2]($x\sigma n$) ..... Population standard deviation of x-data
[F3]($x\sigma n-1$) ..... Sample standard deviation of x-data
[F4](▽) ..... Representative calculation menu

• Representative Menu

[F4](▽)

[F1](Mod) ..... Mode value for input data
[F2](Med) ..... Median value for input data
[F3](Max) ..... Maximum value for input data
[F4](Min) ..... Minimum value for input data

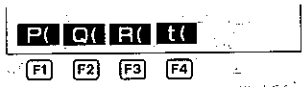
• Sum Data Menu

[F5](Σ)

[F1](Σx^2) ..... Sum of squares of x-data
[F2](Σx) ..... Sum of x-data
[F3](n) ..... Number of x-data items

• Probability Distribution Menu

[F6](PQR)



[F1](P ( ) ..... Probability P (t) value
[F2](Q ( ) ..... Probability Q (t) value
[F3](R ( ) ..... Probability R (t) value
[F4](t ( ) ..... Normalized variation t (x)

4-2 Paired-Variable Statistical Calculations

You should use the Regression Mode to perform paired-variable statistical calculations. In this mode, you can perform linear regression, logarithmic regression, exponential regression, and power regression.

■To Enter the Regression Mode without Data Storage

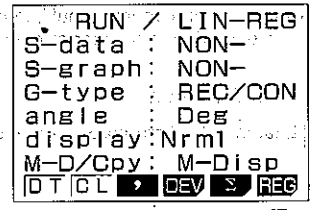
Highlight the **REG** icon on the Main Menu.

[MENU]

Press [EXE] or [4] to display the Regression (REG) Mode.

[EXE] (or [4])

The first line of the REG Mode Set Up Display should show "S-data : NON-". If it shows "S-data : STO" you have to change the set up using the procedure described on page 20.



The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

[F1](DT) ..... Inputs data
[F2](CL) ..... Clears data
[F3](,) ..... Inputs comma between x- and y-data
[F4](DEV) ..... Statistical menu
[F5](Σ) ..... Sum data menu
[F6](REG) ..... Regression/estimated value menu

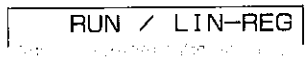
The unit uses the following value memories to store values. Do not use these memories for storage if you plan to perform statistical operations.

Value Memory	P	Q	R	U	V	W
Statistical Data	Σy^2	Σy	Σxy	Σx^2	Σx	n

•When drawing a graph for paired-variable statistical data, STAT GRAPH must be set to the DRAW Mode (page 20).

■To Enter the Linear Regression Mode

[SHIFT] [SET UP] ▼▼▼▼
[F1](LIN) [EXIT]



The linear regression formula is $y = A + Bx$.

• To input data for linear regression

Example 1 **To input the data 10/20, 20/30, 20/30, 40/50**

[SHIFT][CLR][F2](Scl)[EXE]
10[F3](,)20[F1](DT)
20[F3](,)30[F1](DT)
[F1](DT)
40[F3](,)50[F1](DT)

Example 2 **To input the data 10/20, 20/30, 20/30, 20/30, 20/30, 20/30, 40/50**

10[F3](,)20[F1](DT)
20[F3](,)30[ALPHA][:]5[F1](DT)
40[F3](,)50[F1](DT)

Note that you can input multiple data pairs by entering the data, pressing [ALPHA][:], and then entering the number of data pairs.

• To delete data

Example 1 **Data input sequence:** 10[F3](,)40[F1](DT)
20[F3](,)20[F1](DT)
30[F3](,)30[F1](DT)
40[F3](,)50[F1](DT)

To delete the 40[F3](,)50[F1](DT) (last data pair entered), press [F2](CL).

Example 2 **Data input sequence:** 10[F3](,)40[F1](DT)
20[F3](,)20[F1](DT)
30[F3](,)30[F1](DT)
40[F3](,)50

To delete the 40[F3](,)50, press [AC].

Example 3 **Data input sequence:** 10[F3](,)40[F1](DT)
20[F3](,)20[F1](DT)
30[F3](,)30[F1](DT)
40[F3](,)50[F1](DT)

To delete the 20[F3](,)20[F1](DT), enter 20[F3](,)20[F2](CL).

■To Enter the Logarithmic Regression Mode

[SHIFT][SETUP][▼][▼][▼][▼]
[F2](LOG)[EXIT]

RUN ⁄ LOG–REG

The logarithmic regression formula is $y = A + B \cdot \ln x$.

• To input data for logarithmic regression

Input data using the same procedures as described for linear regression on page 86.

• To delete data

Delete data using the same procedures as described for linear regression on page 86.

The following shows the equivalent values between linear regression and logarithmic regression.

Linear Regression	Logarithmic Regression
Σx	$\Sigma \ln x$
Σx^2	$\Sigma (\ln x)^2$
Σxy	$\Sigma \ln x \cdot y$

■To Enter the Exponential Regression Mode

[SHIFT][SETUP][▼][▼][▼][▼]
[F3](EXP)[EXIT]

RUN ⁄ EXP–REG

The exponential regression formula is $y = A \cdot e^{B \cdot x}$ ($\ln y = \ln A + Bx$).

• To input data for exponential regression

Input data using the same procedures as described for linear regression on page 86.

• To delete data

Delete data using the same procedures as described for linear regression on page 86.

The following shows the equivalent values between linear regression and exponential regression.

Linear Regression	Exponential Regression
Σy	$\Sigma \ln y$
Σy^2	$\Sigma (\ln y)^2$
Σxy	$\Sigma x \cdot \ln y$

■To Enter the Power Regression Mode

[SHIFT][SETUP]▼▼▼▼
[F4](PWR)[EXIT]

```
RUN / PWR-REG
```

The power regression formula is $y = A \cdot x^B$ ($\ln y = \ln A + B \ln x$).

• To input data for power regression

Input data using the same procedures as described for linear regression on page 86.

• To delete data

Delete data using the same procedures as described for linear regression on page 86.

The following shows the equivalent values between linear regression and power regression.

Linear Regression	Power Regression
Σx	$\Sigma \ln x$
Σx^2	$\Sigma (\ln x)^2$
Σy	$\Sigma \ln y$
Σy^2	$\Sigma (\ln y)^2$
Σxy	$\Sigma \ln x \cdot \ln y$

■To Enter the Regression Mode with Data Storage

[MENU](REG)[EXE] (or [4])

The first line of the REG Mode Set Up Display should show "S-data : STO". If it shows "S-data : NON-" you have to change the set up using the procedure described on page 20.

```
RUN / LIN-REG
S-data : STO
S-graph: NON-
G-type : REC/CON
angle  : Deg
display:Nrml
M-D/Cpy: M-Disp
DT EDIT ▪ DEV Σ REG
F1 F2 F3 F4 F5 F6
```


The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

[F1](DT) ..... Inputs data
[F2](EDIT) ..... Displays an edit function menu
[F3](,) ..... Inputs comma between x- and y-data
[F4](DEV) ..... Statistical menu
[F5](Σ) ..... Sum data menu
[F6](REG) ..... Regression/estimated value menu

- Σx^2, Σx, n, Σy^2, Σy, and Σxy data are stored in their own memory area, and so they do not use value memories.

• To input data

The following input procedures can be used to input data for linear, logarithmic, exponential, and power regression.

Example 1 **To input the data 10/20, 20/30, 20/30, 40/50**

Before actually beginning data input, use the following sequence to delete any statistical data stored in memory.

[F2](EDIT)[F3](ERS)[F1](YES)
10[F3](,)20[F1](DT)
20[F3](,)30[F1](DT)
[F1](DT)
40[F3](,)50[F1](DT)

Example 2 **To input the data 10/20, 20/30, 20/30, 20/30, 20/30, 20/30, 40/50**

10[F3](,)20[F1](DT)
20[F3](,)30[ALPHA][:]5[F1](DT)
40[F3](,)50[F1](DT)

Note that you can input multiple data pairs by entering the data, pressing [ALPHA][:], and then entering the number of data pairs.

• To edit data

To change, delete, insert, or clear data, press [F2](EDIT) to display the edit function menu and then perform the same procedures as those described for single-variable data on pages 81 to 83.

■Performing Paired-Variable Calculations

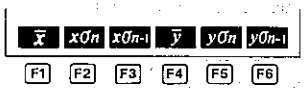
After inputting the data, select the type of operation you want from the function menu at the bottom of the REG Mode set up display. Press one of the following function keys to display a menu of available operations.

[F4](DEV) ..... Statistical menu
[F5](Σ) ..... Sum data menu
[F6](REG) ..... Regression/estimated value menu

Each of these menus is described in detail below.

• Statistical Menu

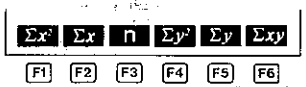
[F4](DEV)



[F1]($\bar{x}$) ..... Mean of x-data
[F2]($x\sigma_n$) ..... Population standard deviation of x-data
[F3]($x\sigma_{n-1}$) ..... Sample standard deviation of x-data
[F4]($\bar{y}$) ..... Mean of y-data
[F5]($y\sigma_n$) ..... Population standard deviation of y-data
[F6]($y\sigma_{n-1}$) ..... Sample standard deviation of y-data

• Sum Data Menu

[F5](Σ)



[F1](Σx^2) ..... Sum of squares of x-data
[F2](Σx) ..... Sum of x-data
[F3](n) ..... Number of items
[F4](Σy^2) ..... Sum of squares of y-data
[F5](Σy) ..... Sum of y-data
[F6](Σxy) ..... Sum of products of x-data and y-data

• Regression/Estimated Value Menu

[F6](REG)

[F1](A) ..... Constant term A
[F2](B) ..... Regression coefficient B
[F3](r) ..... Correlation coefficient r
[F4]($\hat{x}$) ..... Estimated value of x
[F5]($\hat{y}$) ..... Estimated value of y

4-3 Things to Remember during Statistical Calculations

Anytime you delete, insert, or otherwise edit statistical data, be sure to press [EXIT] and then [F6](CAL) to re-calculate the statistical results before inputting new data or performing any other calculation. You should also press [EXIT] followed by [F6](CAL) after you delete the statistical data memory using Scl ([SHIFT][CLR][F2](Scl)).

4-4 Examples of Statistical Calculations

The following are the formulas used by the unit to calculate standard deviation and mean.

•Standard Deviation

$$\sigma_n = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n}} = \sqrt{\frac{\Sigma x^2-(\Sigma x)^2/n}{n}}$$

[Using all data from a finite population to determine the standard deviation for the population]

$$\sigma_{n-1} = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}} = \sqrt{\frac{\Sigma x^2-(\Sigma x)^2/n}{n-1}}$$

[Using sample data from a population to determine the standard deviation for the population]

•Mean

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{\Sigma x}{n}$$

Example	Operation	Display
Data 55, 54, 51, 55, 53, 53, 54, 52	[SHIFT][SETUP]▼▼[F2](NON)[EXIT]	
	[SHIFT][CLR][F2](Scl)[EXE][EXIT] (Clears memory)	**0.**
	55[F1](DT)**54**[F1](DT)	
	51[F1](DT)**55**[F1](DT)	
	53[F1](DT)[F1](DT)**54**[F1](DT)	
	52[F1](DT)	**52.**
*You can press the function keys to obtain results in any sequence.		
	(Standard deviation σ_n) [F4](DEV)[F2]($x\sigma_n$)[EXE]	**1.316956719**
	(Standard deviation σ_{n-1}) [F3]($x\sigma_{n-1}$)[EXE]	**1.407885953**
	(Mean $\bar{x}$) [F1]($\bar{x}$)[EXE]	**53.375**
	(Number of data n) [EXIT][F5](Σ)[F3](n)[EXE]	**8.**
	(Sum total Σx) [F2](Σx)[EXE]	**427.**
	(Sum of squares Σx^2) [F1](Σx^2)[EXE]	**22805.**

To calculate the deviation of the unbiased variance, the difference between each datum, and mean of the above data	(Continuing) EXIT F4(DEV)	
	F3	
	$(x\sigma_{n-1})$ x^2 EXE	1.982142857
	55 − F1$(\bar{x})$ EXE	1.625
	54 − F1$(\bar{x})$ EXE	0.625
	51 − F1$(\bar{x})$ EXE	−2.375
	⋮	⋮
Determine the following: P distribution Q distribution R distribution t distribution	EXIT F6(PQR)	
	F1(P( )0.2) EXE	0.57926
	F2(Q( )0.25) EXE	0.098706
	F3(R( )3) EXE	1.35E−03
	F4(t( )58) EXE	3.511884584
To calculate x and σ_{n-1} for the following data	SHIFT SETUP ▼ ▼ F1(STO) EXIT	
	F2(EDIT) F3(ERS) F1(YES)	0.
	110 F3(;) 10 F1(DT)	110.
	130 F3(;) 31 F1(DT)	130.
	150 F3(;) 24 F1(DT)	150.
	170 F1(DT) F1(DT)	170.
		170.
	190 F1(DT) F1(DT) F1(DT)	190.
		190.
		190.
	F5(Σ) F3(n) EXE	70.
	EXIT F4(DEV) F1$(\bar{x})$ EXE	137.7142857
	F3$(x\sigma_{n-1})$ EXE	18.42898069
To determine Med, Max and Min.	F4(▽) F2(Med) EXE	130.
	F3(Max) EXE	190.
	F4(Min) EXE	110.

Class no.	Value	Frequency
1	110	10
2	130	31
3	150	24
4	170	2
5	190	3

• Regression

The following are the formulas the unit uses to calculate constant term A and regression coefficient B for the regression formula $y = A + Bx$.

$$A = \frac{\Sigma y - B \cdot \Sigma x}{n} \qquad B = \frac{n \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{n \cdot \Sigma x^2 - (\Sigma x)^2}$$

The following is the formula the unit uses to calculate correlation coefficient r and estimated values of x and y.

$$r = \frac{n \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{\sqrt{\{n \cdot \Sigma x^2 - (\Sigma x)^2\}\{n \cdot \Sigma y^2 - (\Sigma y)^2\}}}$$

$$\hat{y} = A + Bx \qquad \hat{x} = \frac{y - A}{B}$$

■Linear Regression

Example	Operation	Display
•Relationship between temperature and the length of a steel bar	SHIFT SETUP ▼ ▼ F2(NON) ▼ ▼ F1(LIN) EXIT	
	SHIFT CLR F2(Scl) EXE EXIT (Clears memory)	0.
	10 F3(,) 1003 F1(DT)	10.
	15 F3(,) 1005 F1(DT)	15.
	20 F3(,) 1010 F1(DT)	20.
	25 F3(,) 1011 F1(DT)	25.
	30 F3(,) 1014 F1(DT)	30.
	(Constant term A) F6(REG) F1(A) EXE	997.4
	(Regression coefficient B) F2(B) EXE	0.56
	(Correlation coefficient r) F3(r) EXE	0.9826073689
	(Length at 18°C) 18 F5$(\hat{y})$ EXE	1007.48
	(Temperature at 1000mm) 1000 F4$(\hat{x})$ EXE	4.642857143
	(Critical coefficient) F3(r) x^2 EXE	0.9655172414
	(Covariance) (EXIT F5(Σ) F6(Σxy) − F3(n) × EXIT F4(DEV) F1$(\bar{x})$ × F4$(\bar{y})$) ÷ (EXIT F5(Σ) F3(n) − 1) EXE	35.

The data in the above table can be used to obtain the terms of the regression formula and the correlation coefficient. Based on the regression formula, the estimated length of the steel bar at 18°C and the temperature when the bar is 1000 mm long can be calculated. The critical coefficient (r^2) and covariance $\left(\frac{\Sigma xy - n \cdot \bar{x} \cdot \bar{y}}{n-1}\right)$ can also be calculated.	

■Logarithmic Regression

- The logarithmic regression formula is $y = A + B \cdot \ln x$.
- Σx, Σx^2, and Σxy are obtained as $\Sigma \ln x$, $\Sigma (\ln x)^2$, and $\Sigma \ln x \cdot y$ respectively.

Example	Operation	Display
	SHIFT SETUP ▼ ▼ F2 (NON) ▼ ▼ F2 (LOG) EXIT	
	SHIFT CLR F2 (Scl) EXE EXIT (Clears memory)	0.
	29 F3 (,) 1.6 F1 (DT)	3.36729583
	50 F3 (,) 23.5 F1 (DT)	3.912023005
	74 F3 (,) 38.0 F1 (DT)	4.304065093
	103 F3 (,) 46.4 F1 (DT)	4.634728988
	118 F3 (,) 48.9 F1 (DT)	4.770684624
	(Constant term A) F6 (REG) F1 (A) EXE	−111.1283976
	(Regression coefficient B) F2 (B) EXE	34.0201475
	(Correlation coefficient r) F3 (r) EXE	0.9940139466
	($\hat{y}$ when $xi = 80$) 80 F5 ($\hat{y}$) EXE	37.94879482
	($\hat{x}$ when $yi = 73$) 73 F4 ($\hat{x}$) EXE	224.1541313

xi	yi
29	1.6
50	23.5
74	38.0
103	46.4
118	48.9

The data in the above table can be used to obtain the terms of the regression formula and the correlation coefficient. Based on the regression formula, estimated value $\hat{y}$ can be obtained for $xi = 80$, and estimated value $\hat{x}$ can be obtained for $yi = 73$.

■Exponential Regression

- The exponential regression formula is $y = A \cdot e^{B \cdot x}$ ($\ln y = \ln A + Bx$).
- Σy is obtained as $\Sigma \ln y$, Σy^2 as $\Sigma (\ln y)^2$, and Σxy as $\Sigma x \cdot \ln y$.

Example	Operation	Display
	SHIFT SETUP ▼ ▼ F2 (NON) ▼ ▼ F3 (EXP) EXIT	
	SHIFT CLR F2 (Scl) EXE EXIT (Clears memory)	0.
	6.9 F3 (,) 21.4 F1 (DT)	6.9
	12.9 F3 (,) 15.7 F1 (DT)	12.9
	19.8 F3 (,) 12.1 F1 (DT)	19.8
	26.7 F3 (,) 8.5 F1 (DT)	26.7
	35.1 F3 (,) 5.2 F1 (DT)	35.1
	(Constant term A) F6 (REG) F1 (A) EXE	30.49758743
	(Regression coefficient B) F2 (B) EXE	−0.04920370831
	(Correlation coefficient r) F3 (r) EXE	−0.997247352
	($\hat{y}$ when $xi = 16$) 16 F5 ($\hat{y}$) EXE	13.87915739
	($\hat{x}$ when $yi = 20$) 20 F4 ($\hat{x}$) EXE	8.574868046

xi	yi
6.9	21.4
12.9	15.7
19.8	12.1
26.7	8.5
35.1	5.2

The data in the above table can be used to obtain the terms of the regression formula and the correlation coefficient. Based on the regression formula, estimated value $\hat{y}$ can be obtained for $xi = 16$, and estimated value $\hat{x}$ can be obtained for $yi = 20$.

■Power Regression

- The power regression formula is $y = A \cdot x^B$ ($\ln y = \ln A + B \ln x$).
- Σx is obtained as $\Sigma \ln x$, Σx^2 as $\Sigma (\ln x)^2$, Σy as $\Sigma \ln y$, Σy^2 as $\Sigma (\ln y)^2$, and Σxy as $\Sigma \ln x \cdot \ln y$.

Example		Operation	Display
xi	*yi*	SHIFT SETUP ▼ ▼ F2 (NON) ▼ ▼ F4 (PWR) EXIT	
28	2410	SHIFT CLR F2 (Scl) EXE EXIT (Clears memory)	0.
30	3033	28 F3 (,) 2410 F1 (DT)	3.33220451
33	3895	30 F3 (,) 3033 F1 (DT)	3.401197382
35	4491	33 F3 (,) 3895 F1 (DT)	3.496507561
38	5717	35 F3 (,) 4491 F1 (DT)	3.555348061
		38 F3 (,) 5717 F1 (DT)	3.63758616
		(Constant term A) F6 (REG) F1 (A) EXE	0.2388010724
		(Regression coefficient B) F2 (B) EXE	2.771866153
		(Correlation coefficient *r*) F3 (*r*) EXE	0.9989062542
		($\hat{y}$ when $xi = 40$) 40 F5 ($\hat{y}$) EXE	6587.67458
		($\hat{x}$ when $yi = 1000$) 1000 F4 ($\hat{x}$) EXE	20.2622568

The data in the above table can be used to obtain the terms of the regression formula and the correlation coefficient. Based on the regression formula, estimated value $\hat{y}$ can be obtained for $xi = 40$, and estimated value $\hat{x}$ can be obtained for $yi = 1000$.

Chapter 5

Using the Matrix Mode

5-1 Before Performing Matrix Calculations
5-2 Modifying a Matrix
5-3 Matrix Calculations
5-4 Matrix Operation Precautions

Chapter 5 Using the Matrix Mode

This calculator provides you with five variable matrices (Mat A through Mat E) and a special matrix answer memory (Mat Ans) that you can use to perform the following types of calculations. Note that the maximum matrix dimension (size) that can be used is 9 × 9.

- **Addition, subtraction, multiplication**
- **Scalar products**
- **Determinants**
- **Transposed matrices**
- **Inverted matrices**
- **Squaring**
- **Row element calculations (editing)**

5-1 Before Performing Matrix Calculations

Before beginning a matrix calculation you have to first enter the correct mode.

■To enter the Matrix Mode

Highlight the **MAT** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] or [5] to display the Matrix Mode.

[EXE] or [5]

```
   RUN / MATRIX
G-type  : REC/CON
angle   : Deg
display:Nrml
M-D/Cpy: M-Disp

Mat Det Trn LIST SEE
```

[F1] [F2] [F3] [F4] [F5]

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

[F1](Mat) ..... For specification of matrix type
[F2](Det) ..... Determinant
[F3](Trn) ..... Transformation
[F4](LIST) ..... Display of matrix list
[F5](SEE) ..... Display of the latest matrix calculation result

About the Matrix Answer Memory (Mat Ans)

Much like the standard Answer Memory (page 30), the Matrix Answer Memory automatically stores the latest matrix calculation result. Note the following points whenever you are using the Matrix Answer Memory.

- Whenever you perform a matrix calculation, the values that make up the result are stored using the applicable matrix dimension. Anything previously stored in Matrix Answer Memory is replaced by the new data.
- Matrix Answer Memory contents are not affected by a matrix substitution operation (page 116).

■Matrix List

Use the matrix list to specify the size of the matrix you want to use.

• To display the matrix list

While the Matrix Mode is displayed, press [F4] for the matrix list.

[F4](LIST)

No dimension preset

2 (row) × 2 (column) matrix

```
MATRIX LIST
▶Mat A  :2×2
 Mat B  :None
 Mat C  :None
 Mat D  :None
 Mat E  :None
 Mat Ans:2×2
EDIT DIM ERS ER·A
```

[F1] [F2] [F3] [F4]

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

[F1](EDIT) ..... Recall of a matrix for editing
[F2](DIM) ..... Setting of matrix dimensions
[F3](ERS) ..... Deletion of selected matrix
[F4](ER·A) ..... Deletion of all matrices

■Matrix Input

You can use either of the two following methods for matrix input.

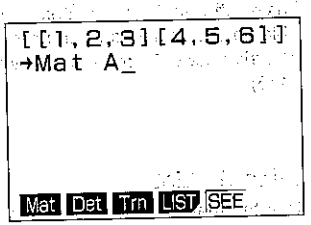
- Inputting component data, and then using [→] to directly assign the data to a matrix (automatic dimensioning).
- Specifying the dimensions (size) of the matrix and then inputting data for each component.

• To directly assign data to a matrix

Example To input the following 2 × 3 matrix as Matrix A.

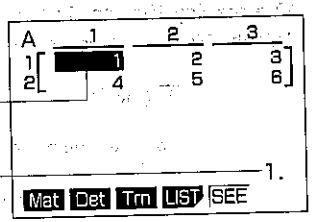
$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{pmatrix}$$

[ALPHA] [[ ] [ALPHA] [[ ] [1] [SHIFT] [,] [2]
[SHIFT] [,] [3] [ALPHA] [ ]] [ALPHA] [[ ]
[4] [SHIFT] [,] [5] [SHIFT] [,] [6]
[ALPHA] [ ]] [ALPHA] [ ]] → [F1] (Mat) [ALPHA] [A]



[F1]

[EXE]



Component cells (up to six rows displayed)

Cell number of currently highlighted cell

- The following shows the data input format and the sequence used to store input data into the matrix. The subscripts indicate row (r) and column (c) locations.

Input Format

$[[a_{11}, a_{12}, ..., a_{1c}]\ [a_{21}, a_{22}, ..., a_{2c}]\ ...\ [a_{r1}, a_{r2}, ..., a_{rc}]]$ ⇨ [F1] (Mat) (matrix name A through E)

Data Input

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1c} \\ a_{21} & a_{22} & \cdots & a_{2c} \\ \vdots & \vdots & & \vdots \\ a_{r1} & a_{r2} & \cdots & a_{rc} \end{bmatrix}$$

Note that the maximum value for both r (number of rows) and c (number of columns) is 9.

- When you use the above procedure to directly assign data to a matrix, the dimensions (size) of the matrix is set automatically.
- A "Mem ERROR" message appears on the display if memory becomes full while you are substituting values in a matrix (page 269).
- You can also use the above procedure to input matrix data in a program.

• To specify the dimensions of a matrix and then input data

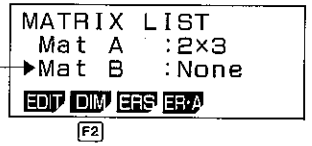
Example To set up a 2-row × 3-column matrix (Matrix B) and assign the following values to it.

$$\begin{pmatrix} 1 & 3 & 5 \\ -2 & 0 & 2 \end{pmatrix}$$

Display the matrix list.

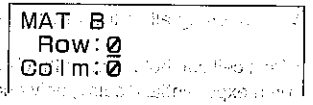
[F4] (LIST)

Use the ▲ and ▼ cursor keys to move the pointer to the matrix you want to use.



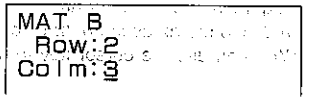
Pointer

[F2] (DIM)

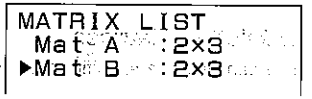


Specify the number of rows and columns you want to use, pressing [EXE] after each input

[2] [EXE] [3] [EXE]



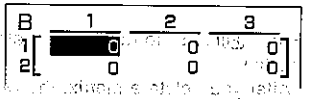
Press [EXIT] to return to the matrix list.



- If the matrix couldn't be created because of lack of memory, "None" appears in the matrix list in place of the dimension (2 × 3).
- Note that you could end the procedure here if you want to.

After making sure that the pointer is located next to the matrix you want to use, press [F1] (EDIT).

[F1] (EDIT)

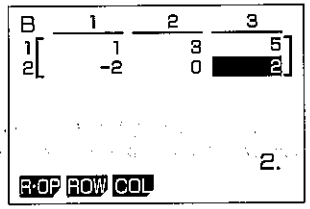


Important

Note that if you input data into a matrix that already contains data, the previous data is replaced with the new data.

Input the value for each cell, pressing [EXE] each time.

[1][EXE][3][EXE][5][EXE]
[(-)][2][EXE][0][EXE][2][EXE]



After inputting all of the values, press [EXIT] to return to the matrix list.

- Each cell can hold a value that is six digits long if positive, or five digits long if negative. With exponential display, only one significant digit is used, with everything from the second digit being cut off.
- Eight bytes of memory are required for each cell. This means that inputting data into a 3 × 3 matrix uses up 72 bytes (3 × 3 = 9 cells × 8 bytes = 72 bytes) of memory.
- You can use the cursor key to move the highlighting around the display.

■Deleting Matrices

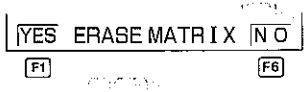
You can delete a specific matrix or all of the matrices stored in memory.

• To delete a specific matrix

Display the matrix list.
Move the pointer next to the matrix you want to delete.

Press [F3](ERS).

[F3](ERS)



Press [F1](YES) to delete the matrix, or [F6](NO) to abort the operation without deleting anything.

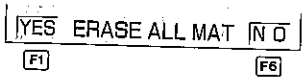
- After you delete a matrix, the word "None" appears to the right of its location in the matrix list.

• To delete all matrices

Display the matrix list.

Press [F4](ER•A).

[F4](ER•A)



Press [F1](YES) to delete all matrices, or [F6](NO) to abort the operation without deleting anything.

5-2 Modifying a Matrix

Once you create a matrix, you can perform any of the following operations to modify it.

- **Swapping of any two rows**
- **Calculation of a scalar product**
- **Scalar product addition**
- **Substitution and recall of values**
- **Row delete, insert, add**
- **Column delete, insert, add**

■Before Modifying a Matrix

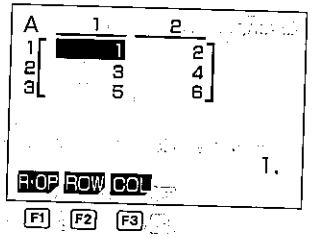
Before starting work with an existing matrix, you must first select it in the matrix list and then display the matrix editing screen.

• To display the matrix editing screen

Example **To display Matrix A, which contains the following data.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

[MENU](MAT)[EXE]
[F4](LIST)
[F1](EDIT)



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

F1(R·OP) ..... Display of menu for swapping of rows, scalar products and addition
F2(ROW) ..... Display of menu for deleting, inserting, and adding rows
F3(COL) ..... Display of menu for deleting, inserting, and adding columns

■Row Operations

The row operations menu lets you swap any two rows, calculate scalar products, add scalar products to another row, and add rows together. Use the following procedure to display the row operation menu.

• To display the row operation menu

In the Matrix Mode, display the matrix list and select the matrix you want to work with.

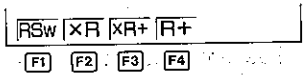
F4(LIST)▼

Display the matrix editing screen.

F1(EDIT)

Display the row operation menu.

F1(R·OP)



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

F1(RSw) ..... Swapping of rows
F2(×R) ..... Calculation of scalar products for specific rows
F3(×R+) ..... Addition of the scalar product of one row to another row
F4(R+) ..... Addition of one row to another

Pressing EXIT returns to the matrix editing menu.

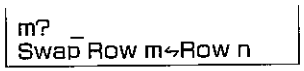
• To swap two rows

Example **To swap rows two and three in the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

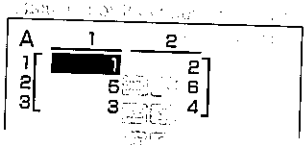
Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F1(R·OP) F1(RSw)



Input the numbers of the rows you want to swap.

2 EXE
3 EXE



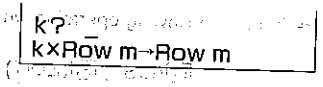
• To calculate a scalar product for a row

Example **To calculate a scalar product of row 2 of the following matrix (Matrix A), by multiplying each element by 4.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

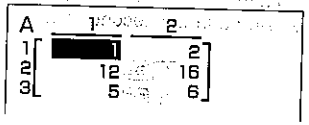
Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F1(R·OP) F2(×R)



Input the numbers you want to multiply by and the number of the row whose scalar product you want to calculate.

4 EXE
2 EXE



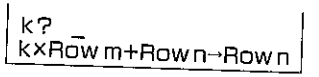
• To add the scalar product of one row to another row

Example **To calculate a scalar product of row 2 of the following matrix (Matrix A), by multiplying each element by 4, and then add the results to row 3.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F1(R·OP) F3(×R+)



Input the numbers you want to multiply by, followed by the number of the row whose scalar product you want to calculate, and then the number of the row you want the results added to.

[4] [EXE]
[2] [EXE]
[3] [EXE]

```
A    1    2
1  [ 1    2 ]
2  [ 3    4 ]
3  [ 17   22]
```

• To add one row to another

Example **To add row 2 to row 3 in the following matrix (Matrix A), and store the result in row 3.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F1](R·OP) [F4](R+)

```
m? _
Row m+Row n→Row n
```

Input the number of the first row and then the number of the second row. The result will be stored in the second row.

[2] [EXE]
[3] [EXE]

```
A    1    2
1  [ 1    2 ]
2  [ 3    4 ]
3  [ 8    10]
```

■Modifying the Contents of a Matrix

You can specify a value for direct substitution in a matrix cell, and you can recall values from a specific cell to perform arithmetic operations on that value.

• To directly substitute value in a matrix cell

Example **To substitute a value of 10 in row 1 column 2 of the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[1] [0] [→] [F1](Mat)
[ALPHA] [A] [ALPHA] [(] [1] [SHIFT] [,] [2]
[ALPHA] [)] [EXE]

```
10→Mat A[1,2]
                10.
```

The following is the basic format for the above procedure.
Mat X [r, c]
X = Matrix name (A through E, or Ans)
r = row number
c = column number

• To perform an arithmetic operation using a matrix value

Example **To multiply the value located at row 2, column 2 in the following matrix (Matrix A) by 5.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F1](Mat)
[ALPHA] [A] [ALPHA] [(] [2] [SHIFT] [,] [2]
[ALPHA] [)] [EXE]

```
Mat A[2,2]
                4.
```

[×] [5] [EXE]

```
Mat A[2,2]
                4.
4.×5
                20.
```

■Deleting, Inserting, and Adding Rows

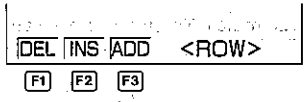
Use the following procedures to delete, insert and add rows in a matrix.

Before starting a row delete, insert or add operation, you must first select the matrix you want to work with and then press [F2](ROW) to display the row editing screen.

First, select and recall the matrix you want to edit.

[MENU](MAT) [EXE]
[F4](LIST) [F1](EDIT)

Next, press [F2](ROW) to display the row editing screen.



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

[F1](DEL) ..... Row deletion
[F2](INS) ..... Row insertion
[F3](ADD) ..... Row addition

Pressing [EXIT] returns to the matrix editing menu.

• To delete a row

Example **To delete row 2 of the following matrix (Matrix A).**

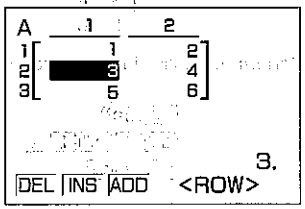
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F2](ROW)

Move the highlighting into the row you want to delete.

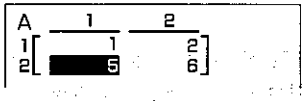
[▼]



[F1]

Perform the delete operation.

[F1](DEL)



• To insert a row

Example **To insert a row between rows 1 and 2 of the following matrix (Matrix A).**

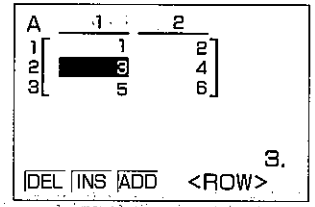
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F2](ROW)

Move the highlighting into the row that you want to be below the newly inserted row.

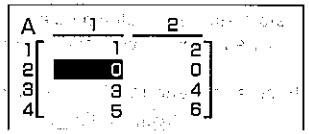
[▼]



[F2]

Perform the insert operation.

[F2](INS)



• To add a row

Example **To add a row below row 3 of the following matrix (Matrix A).**

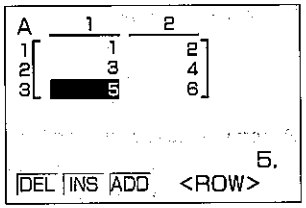
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F2](ROW)

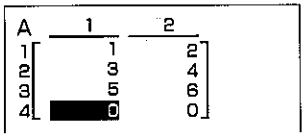
Move the highlighting into the row that you want to be above the newly added row.

(▼)(▼)



Perform the add operation.

F3(ADD)



■Deleting, Inserting, and Adding Columns

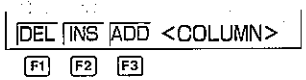
Use the following procedures to delete, insert and add columns in a matrix.

Before starting a column delete, insert or add operation, you must first select the matrix you want to work with and then press F3(COL) to display the column editing screen.

First, select and recall the matrix you want to edit.

MENU(MAT)EXE
F4(LIST) F1(EDIT)

Next, press F3(COL) to display the column editing screen.



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

F1(DEL) ..... Column deletion
F2(INS) ..... Column insertion
F3(ADD) ..... Column addition

Pressing EXIT returns to the matrix editing menu.

• To delete a column

Example **To delete column 2 of the following matrix (Matrix A).**

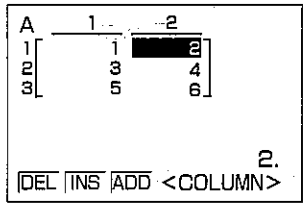
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F3(COL)

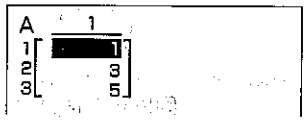
Move the highlighting into the column you want to delete.

(▶)



Perform the delete operation.

F1(DEL)



• To insert a column

Example **To insert a column between columns 1 and 2 of the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

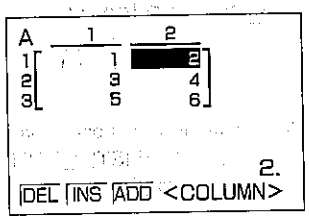
Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F3(COL)

A313025-28

Move the highlighting into the column that you want to be to the right of the newly inserted column.

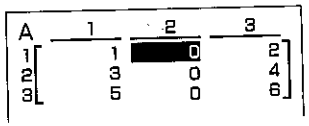
(▶)



F2

Perform the insert operation.

F2(INS)



• To add a column

Example **To add a column to the right of column 2 of the following matrix (Matrix A).**

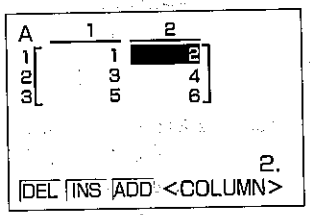
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F3(COL)

Move the highlighting into the column that you want to be to the left of the newly added column.

(▶)



F3

Perform the add operation.

F3(ADD)

5-3 Matrix Calculations

This section describes how to actually perform matrix calculations. To perform a calculation, you must press the Matrix Mode function key (page 98) that puts in the correct calculation mode. The following shows the modes you can enter and the function keys you should press to enter the modes.

F1(Mat) ..... For specification of matrix type
F2(Det) ..... Determinant
F3(Trn) ..... Transformation

■ Arithmetic Operations

Use the procedures described here to add, subtract, and multiply matrices. Note that you cannot use division with matrices.

• To add matrices

Example **To add the following two matrices.**

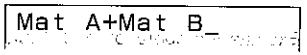
Matrix A $\begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix}$ **Matrix B** $\begin{pmatrix} 2 & 3 \\ 2 & 1 \end{pmatrix}$

Perform the following operation while in the Matrix Mode.

F1(Mat)

Input the name of the first matrix.

ALPHA A +
F1(Mat)



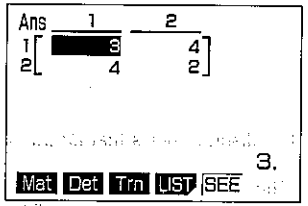
Input the name of the second matrix.

ALPHA B

F1

Execute the operation and display its result.

EXE



The display shows that **Matrix A + Matrix B** = $\begin{pmatrix} 3 & 4 \\ 4 & 2 \end{pmatrix}$.

*The dimensions (sizes) of the two matrices being added must be identical. If you try to add matrices of different dimensions, a "Dim ERROR" will occur.
*The result of an addition operation is also stored in the Matrix Answer Memory (Mat Ans), automatically replacing any data previously stored there.
*You can also store the result of a matrix addition operation into a third matrix (page 116). When you do so, the result is not stored in the Matrix Answer Memory.

• To subtract matrices

Example **To subtract Matrix B from Matrix A. The following shows the contents of the two matrices.**

Matrix A $\begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix}$ **Matrix B** $\begin{pmatrix} 2 & 3 \\ 2 & 1 \end{pmatrix}$

Perform the following operation while in the Matrix Mode.

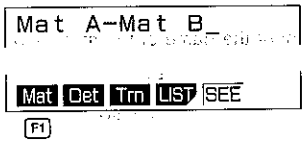
[F1](Mat)

Input the name of the matrix you want to subtract from.

[ALPHA][A][−]
[F1](Mat)

Input the name of the matrix you want to subtract.

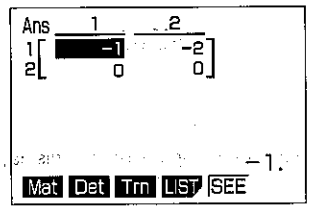
[ALPHA][B]



[F1]

Execute the operation and display its result.

[EXE]



The display shows that **Matrix A − Matrix B** = $\begin{pmatrix} -1 & -2 \\ 0 & 0 \end{pmatrix}$.

*The dimensions (sizes) of the two matrices being subtracted must be identical. If you try to subtract matrices of different dimensions, a "Dim ERROR" will occur.
*The result of an subtraction operation is also stored in the Matrix Answer Memory (Mat Ans), automatically replacing any data previously stored there.

*You can also store the result of a matrix subtraction operation into a third matrix (page 116). When you do so, the result is not stored in the Matrix Answer Memory.

• To multiply matrices

Example **To multiply Matrix B by Matrix A. The following shows the contents of the two matrices.**

Matrix A $\begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix}$ **Matrix B** $\begin{pmatrix} 2 & 3 \\ 2 & 1 \end{pmatrix}$

Perform the following operation while in the Matrix Mode.

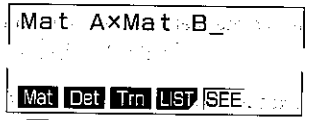
[F1](Mat)

Input the name of the matrix you want to multiply.

[ALPHA][A][×]
[F1](Mat)

Input the name of the matrix you want to multiply by.

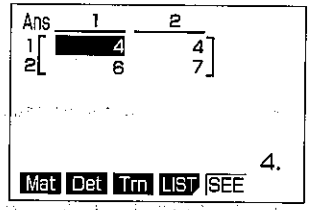
[ALPHA][B]



[F1]

Execute the operation and display its result.

[EXE]



The display shows that **Matrix A × Matrix B** = $\begin{pmatrix} 4 & 4 \\ 6 & 7 \end{pmatrix}$.

*The dimensions (sizes) of the two matrices being multiplied must be identical. If you try to multiply matrices of different dimensions, a "Dim ERROR" will occur.
*The result of a multiplication operation is also stored in the Matrix Answer Memory (Mat Ans), automatically replacing any data previously stored there.
*You can also store the result of a matrix multiplication operation into a third matrix (page 116). When you do so, the result is not stored in the Matrix Answer Memory.

• To store the result of an arithmetic operation in a third matrix

Example **To add the following two matrices and store the result in Matrix E.**

Matrix A $\begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix}$ **Matrix B** $\begin{pmatrix} 2 & 3 \\ 2 & 1 \end{pmatrix}$

Perform the following operation while in the Matrix Mode.

F1(Mat)

Input the name of the first matrix.

ALPHA A

+

•You could also press − (for subtraction) or × (for multiplication) here.

F1(Mat)

Input the name of the second matrix.

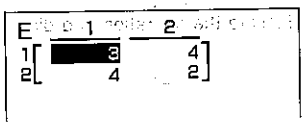
ALPHA B

Name the matrix where you want the result stored.

→F1(Mat)ALPHA E

Execute the operation and display the matrix where the result is stored.

EXE



•The result of the above operation is not stored in the Matrix Answer Memory.

■Calculating a Scalar Product

To calculate a scalar product, you specify the multiplier and then the matrix name (Matrix A to Matrix E, or Mat Ans). Next you press the EXE key to perform the multiplication.

• To calculate a scalar product

Example **To calculate the scalar product for the following matrix (Matrix A) by multiplying by 4.**

$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$

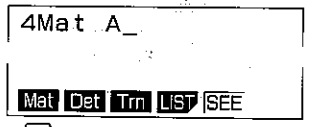
Perform the following operation while in the Matrix Mode.

Input the multiplier

4

Specify the name of the matrix you want to multiply.

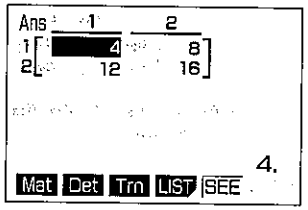
F1(Mat)ALPHA A



F1

Execute the operation and display the matrix where the result is stored.

EXE



The display shows that the **scalar product of Matrix A is** $\begin{pmatrix} 4 & 8 \\ 12 & 16 \end{pmatrix}$.

*The result of a scalar product operation is also stored in the Matrix Answer Memory (Mat Ans), automatically replacing any data previously stored there.

*You can also store the result of a scalar product operation into a third matrix (see below). When you do so, the result is not stored in the Matrix Answer Memory.

• To store the result of a scalar product operation in another matrix

Example **To calculate the scalar product for the following matrix (Matrix A) by multiplying by 4, and store the result in Matrix E.**

$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$

Perform the following operation while in the Matrix Mode.

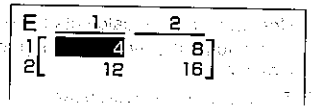
4F1(Mat)ALPHA A

Name the matrix where you want the result stored.

→F1(Mat)ALPHA E

Execute the operation and display the matrix where the result is stored.

EXE



•The result of the above operation is not stored in the Matrix Answer Memory.

■Determinants

Determinants are calculated automatically using the formulas shown below. Note that after you calculate a determinant, you can assign it to a value memory.

•2 × 2 matrix

$$|A| = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$$

$$= a_{11}\,a_{22} - a_{12}\,a_{21}$$

•3 × 3 matrix

$$|A| = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

$$= a_{11}\,a_{22}\,a_{33} + a_{12}\,a_{23}\,a_{31} + a_{13}\,a_{21}\,a_{32} - a_{11}\,a_{23}\,a_{32} - a_{12}\,a_{21}\,a_{33} - a_{13}\,a_{22}\,a_{31}$$

• To calculate a determinant

Example **To calculate the determinant for the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ -1 & -2 & 0 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F2(Det)
F1(Mat)

Input the name of the matrix whose determinant you want to calculate

ALPHA A

Execute the operation and display the result.

EXE

```
Det Mat A
                -9.
Mat Det Trn LIST SEE
F1  F2
```

The display shows that the **determinant of Matrix A = −9.**

*Note that you can calculate the determinant for square matrices (same number of rows and columns) only. Attempting to invert a matrix that is not square results in a "Dim ERROR."

*The result of an invert operation is also stored in the Matrix Answer Memory (Mat Ans), automatically replacing any data previously stored there.

• To calculate a determinant and assign the result to a value memory

Example **To calculate the determinant for the following matrix (Matrix A), and assign the result to value memory A.**

$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ -1 & -2 & 0 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F2(Det)
F1(Mat)

Input the name of the matrix whose determinant you want to calculate

ALPHA A

Assign the result to the value memory.

→ ALPHA A

•You can assign the result to any value memory: A through Z, r, or θ.

Execute the operation and assign the result.

EXE

```
Det Mat A→A
                -9.
```

■Transposing a Matrix

Transposing a matrix causes its rows to become columns and its columns to become rows. You can transpose any matrix in the matrix list (Matrix A through Matrix E) or the matrix in the Matrix Answer Memory.

• To transpose a matrix

Example **To transpose the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F3(Trn)

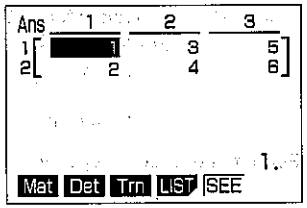
Specify the name of the matrix you want to transpose.

F1(Mat) ALPHA A

```
Trn Mat A_
Mat Det Trn LIST SEE
        F3
```

Execute the operation and display the transposed matrix.

[EXE]



The display shows that **transposing Matrix A produces** $\begin{pmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{pmatrix}$.

*The result of a transpose operation is also stored in the Matrix Answer Memory (Mat Ans), automatically replacing any data previously stored there.
*You can also store the result of a transpose operation into a third matrix (see below). When you do so, the result is not stored in the Matrix Answer Memory.

• To store the result of a transpose operation in another matrix

Example **To transpose the following matrix (Matrix A), and store the result in Matrix E.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

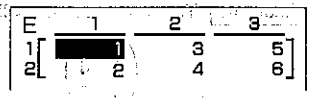
[F3](Trn)[F1](Mat)[ALPHA][A]

Name the matrix where you want the result stored.

[→][F1](Mat)[ALPHA][E]

Execute the operation and display the matrix where the result is stored.

[EXE]



The result of the above operation is not stored in the Matrix Answer Memory.

■ Inverting a Matrix

Matrices are inverted automatically according to the following rules, where A is a matrix and A^{-1} is its inverse.

•A matrix being inverted must satisfy the following conditions

$$A A^{-1} = A^{-1} A = E = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

•The following shows the formula use to invert Matrix A, shown below, into inverse matrix A^{-1}.

$$A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$$

$$A^{-1} = \frac{1}{ad - bc} \begin{pmatrix} d & -b \\ -c & a \end{pmatrix}$$

In the above: $ad - bc \neq 0$

• To invert a matrix

Example **To invert the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

Specify the name of the matrix you want to invert.

[F1](Mat)[ALPHA][A]

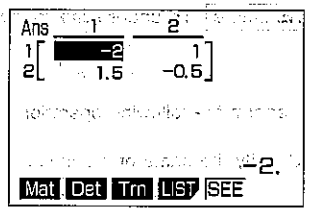
Specify matrix inversion.

[SHIFT][x^{-1}]

[F1]

Execute the operation and display the inverted matrix.

[EXE]



The display shows that **inverting Matrix A produces** $\begin{pmatrix} -2 & 1 \\ 1.5 & -0.5 \end{pmatrix}$.

*Note that a matrix cannot be inverted if ad − bc = 0 (which makes the determinant zero). Attempting to invert such a matrix results in an "Ma ERROR."
*Note that you can only invert square matrices, which have the same number of rows and columns. Attempting to invert a matrix that is not square results in a "Dim ERROR."
*The result of an invert operation is also stored in the Matrix Answer Memory (Mat Ans), automatically replacing any data previously stored there.
*You can also store the result of a invert operation into a third matrix (see below). When you do so, the result is not stored in the Matrix Answer Memory.

• To store the result of an invert operation in another matrix

Example **To invert the following matrix (Matrix A), and store the result in Matrix E.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

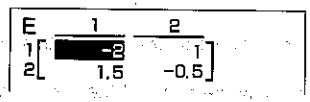
F1(Mat)ALPHA A SHIFT x^{-1}

Name the matrix where you want the result stored.

→F1(Mat)ALPHA E

Execute the operation and display the matrix where the result is stored.

EXE



The result of the above operation is not stored in the Matrix Answer Memory.

■Squaring a Matrix

Use the operations described below to square a matrix.

• To square a matrix

Example **To square the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$$

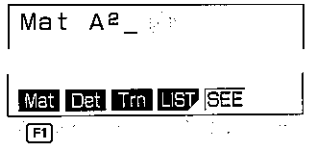
Perform the following operation while in the Matrix Mode.

Specify the name of the matrix you want to square.

F1(Mat)ALPHA A

Specify squaring.

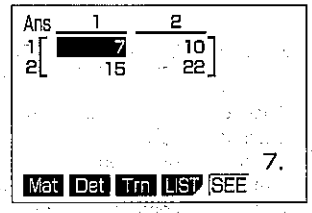
x^2



F1

Execute the operation and display the squaring matrix.

EXE



The display shows that squaring Matrix A produces $\begin{pmatrix} 7 & 10 \\ 15 & 22 \end{pmatrix}$.

*The result of an squaring operation is also stored in the Matrix Answer Memory (Mat Ans), automatically replacing any data previously stored there.
*You can also store the result of a squaring operation into a third matrix (see below). When you do so, the result is not stored in the Matrix Answer Memory.

• To store the result of an squaring operation in another matrix

Example **To square the following matrix (Matrix A), and store the result in Matrix E.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

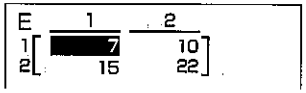
F1(Mat)ALPHA A x^2

Name the matrix where you want the result stored.

→F1(Mat)ALPHA E

Execute the operation and display the matrix where the result is stored.

EXE



The result of the above operation is not stored in the Matrix Answer Memory.

5-4 Matrix Operation Precautions

- Calculation of determinants and inverse matrices uses the elimination method, so errors (such as dropped digits) may be generated.
- If a matrix calculation result becomes too large to fit into the Matrix Answer Memory (Mat Ans), a "Mem ERROR" occurs.
- Matrix operations are performed individually on each element, and so calculation may require considerable time.
- The calculation precision of matrix calculations is 10 digits, ±1.

Chapter 6

Equation Calculations

6-1 Before Beginning an Equation Calculation
6-2 Linear Equations with Two Unknowns
6-3 Linear Equations with Three Unknowns
6-4 Quadratic Equations

Chapter 6 Equation Calculations

Your graphic calculator can solve the following three types of equations:

- **Linear equations with two unknowns**
- **Linear equations with three unknowns**
- **Quadratic equations**

6-1 Before Beginning an Equation Calculation

Before beginning an equation calculation you have to first enter the correct mode, and you must also clear the equation memories of any data that might be left over from a previous calculation.

■To Enter an Equation Calculation Mode

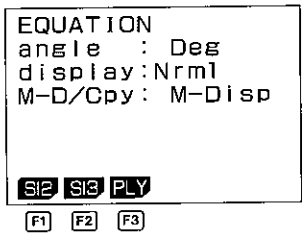
Highlight the **EQUA** icon on the Main Menu:

[MENU]

[▲][▼][◀][▶]

Press [EXE] or [7] to display the Equation (EQUA) Mode.

[EXE] or [7]



The following are the types of equations that can be selected from the function menu at the bottom of the display. Press the function key below the type of equation you want to solve.

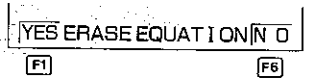
[F1](SI2) ..... Linear equation with two unknowns
[F2](SI3) ..... Linear equation with three unknown
[F3](PLY) ..... Quadratic equation

■To clear the equation memories

Use the following procedure to clear the equation memories prior to performing a calculation, etc.

Press one of the function keys ([F1](SI2) – [F3](PLY))

[F3](ERS)



Press [F1](YES) to clear the equation memories, or [F6](NO) to abort the clear operation without clearing anything.

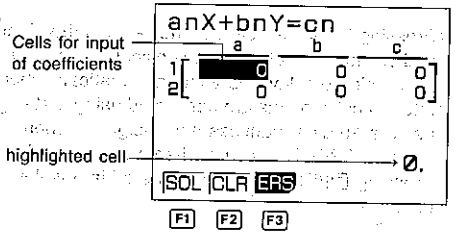
6-2 Linear Equations with Two Unknowns

You can use the procedures described here to solve linear equations with two unknowns that match the following formats (when $a_1b_2 - b_1a_2 \neq 0$):

$a_1x + b_1y = c_1$
$a_2x + b_2y = c_2$

■To Enter the Linear Equation Mode for Two Unknowns

[MENU](EQUA)[EXE](or[7])
[F1](SI2)



The following are the operations that are available from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

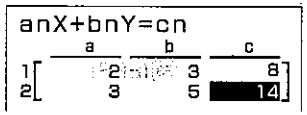
[F1](SOL) ..... Solves the equation
[F2](CLR) ..... Clears all input coefficients
[F3](ERS) ..... Clears the equation memory. Perform this operation before inputting a new equation.

■To Solve a Linear Equation with Two Unknowns

Example **To solve the following linear equations for x and y:**
$2x+3y=8$
$3x+5y=14$

Input each coefficient.

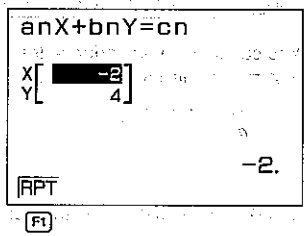
[2] [EXE] [3] [EXE] [8] [EXE]
[3] [EXE] [5] [EXE] [1] [4] [EXE]



- Each time you press [EXE], the input value is registered in the highlighted cell. Each press of [EXE] inputs values in the following sequence:
  coefficient a_1 → coefficient b_1 → coefficient c_1 → coefficient a_2 → coefficient b_2 → coefficient c_2
- You can input fractions and value memory contents as coefficients.

After inputting the coefficients, solve the equations.

[F1](SOL)



- Pressing the [a⇄] key causes the value in the highlighted cell to switch between fraction and decimal formats. Any time calculation causes a value to exceed the allowable range for fraction display, the value automatically changes to decimal format.
- Internal calculations are performed using a 13-digit mantissa, but results are displayed using a 10-digit mantissa and 2-digit exponent.
- An "Ma ERROR" occurs whenever the unit is unable to solve the equations.
- Pressing [F1](RPT) returns to the initial display of the Linear Equation Mode for two unknowns.

6-3 Linear Equations with Three Unknowns

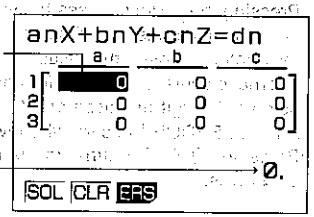
Use the procedures described here to solve linear equations with three unknowns that match the following formats (when $a_1b_2c_3+a_3b_1c_2+a_2b_3c_1-c_1b_2a_3-c_2b_3a_1-c_3b_1a_2\neq 0$):

$a_1x+b_1y+c_1z=d_1$
$a_2x+b_2y+c_2z=d_2$
$a_3x+b_3y+c_3z=d_3$

■To Enter the Linear Equation Mode for Three Unknowns

[MENU](EQUA)[EXE](or[7])
[F2](SI3)

Cells for input of coefficients

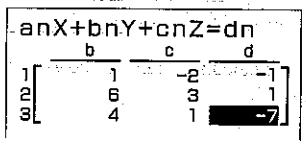


■To Solve a Linear Equation with Three Unknowns

Example **To solve the following linear equations for x, y, and z:**
$4x+y-2z=-1$
$x+6y+3z=1$
$-5x+4y+z=-7$

Input each coefficient.

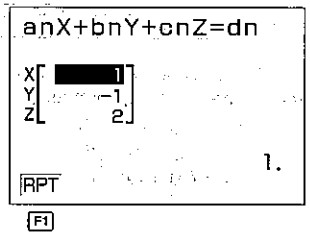
[4] [EXE] [1] [EXE] [(-)] [2] [EXE] [(-)] [1] [EXE]
[1] [EXE] [6] [EXE] [3] [EXE] [1] [EXE]
[(-)] [5] [EXE] [4] [EXE] [1] [EXE] [(-)] [7] [EXE]



- Each time you press [EXE], the input value is registered in the highlighted cell. Each press of [EXE] inputs values in the following sequence:
  coefficient a_1 → coefficient b_1 → coefficient c_1 → coefficient d_1 → coefficient a_2 → coefficient b_2 → coefficient c_2 → coefficient d_2 → coefficient a_3 → coefficient b_3 → coefficient c_3 → coefficient d_3
- You can input fractions and value memory contents as coefficients.

After inputting the coefficients, solve the equations.

F1(SOL)



- Pressing the a⇔b/c key causes the value in the highlighted cell to switch between fraction and decimal forms. Any time calculation causes a value to exceed the allowable range for fraction display, the value automatically changes to decimal format.
- Internal calculations are performed using a 13-digit mantissa, but results are displayed using a 10-digit mantissa and 2-digit exponent.
- An "Ma ERROR" occurs whenever the unit is unable to solve the equations.
- Pressing F1(RPT) returns to the initial display of the Linear Equation Mode for three unknowns.

Depending on the coefficients that you use, it may take considerable time for the calculation result of simultaneous linear equations with three unknowns to appear on the display. Failure of a result to appear immediately does not mean that the unit is not functioning properly.

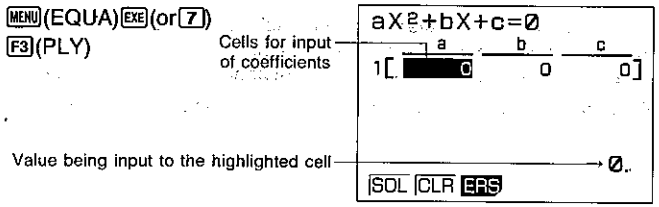
6-4 Quadratic Equations

This calculator can also solve quadratic equations that match the following format (when $a \neq 0$):

$$ax^2 + bx + c = 0$$

■To Enter the Quadratic Equation Mode

MENU(EQUA)EXE(or 7)
F3(PLY)

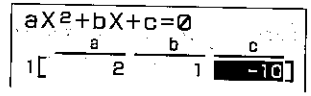


■To Solve a Quadratic Equation

Example **To solve the following quadratic equation:**
$2x^2 + x - 10 = 0$

Input each coefficient.

2 EXE 1 EXE (−) 1 0 EXE



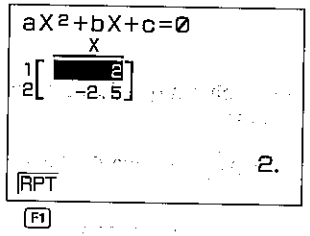
- Each time you press EXE, the input value is registered in the highlighted cell. Each press of EXE inputs values in the following sequence:

coefficient a → coefficient b → coefficient c

- You can input fractions and value memory contents as coefficients.

After inputting the coefficients, solve the equations.

F1(SOL)



- Pressing the a⇔b/c key causes the value in the highlighted cell to switch between fraction and decimal forms. Any time calculation causes a value to exceed the allowable range for fraction display, the value automatically changes to decimal format.
- Internal calculations are performed using a 13-digit mantissa, but results are displayed using a 10-digit mantissa and 2-digit exponent.
- An "Ma ERROR" occurs whenever the unit is unable to solve the equations.
- Pressing F1(RPT) returns to the initial display of the Quadratic Equation Mode.

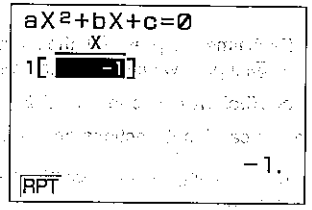
■Quadratic Equations that Produce Single-value Solutions or Imaginary Number Solutions

The following examples illustrate how single-value solutions and imaginary number solutions.

• To solve a quadratic equation that produces a single-value solution

Example To solve the following quadratic equation:
$x^2+2x+1=0$

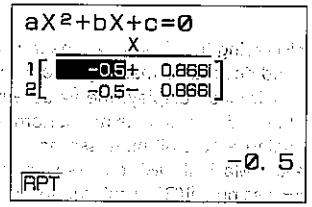
1 EXE 2 EXE 1 EXE
F1(SOL)



• To solve a quadratic equation that produces an imaginary number solution

Example To solve the following quadratic equation:
$x^2+x+1=0$

1 EXE 1 EXE 1 EXE
F1(SOL)



•When a solution includes real and imaginary number parts, you can use the cursor keys to move the highlighting around the display to check each value individually.

■Changing Coefficients

You can change a coefficient either before or after you register it by pressing EXE. Note that the following procedure applies to simultaneous linear equations with two or three unknowns, and to quadratic equations.

• To change a coefficient before registering it with EXE

Press the AC key to clear the current value and then input another one.

• To change a coefficient after registering it with EXE

Use the cursor keys to highlight the cell that contains the coefficient that you want to change. Next, input the value that you want to change to.

■To Clear All the Coefficients

Note that the following procedure applies to simultaneous linear equations with two or three unknowns, and to quadratic equations.

Press the F2(CLR) function key.

This operation clears all the coefficients to zero.

■What to Do When an Error Occurs

Note that the following procedure applies to simultaneous linear equations with two or three unknowns, and to quadratic equations.

• Error during coefficient value input

Press the AC key to clear the error and return to the value that was registered for the coefficient before you input the value that generated the error. Try inputting a new value again.

• Error during calculation

Press the AC key to clear the error and display coefficient a. Try inputting values for the coefficients again.

•Note that even when you press the AC key, the values assigned for coefficients are retained.

Chapter 7

Graphing

7-1 About the Graphing Function
7-2 Rectangular Coordinate Graphs
7-3 Polar Coordinate Graphs
7-4 Parametric Graphs
7-5 Inequality Graphs
7-6 Integration Graphs
7-7 Probability Distribution Graphs
7-8 Single-Variable Statistical Graphs
7-9 Paired-Variable Statistical Graphs
7-10 Storing Functions In Memory
7-11 Other Graph Functions
7-12 Some Graphing Examples

Chapter 7 Graphing

This chapter explains everything you need to know to fully use the versatile graphing capabilities of the unit.

7-1 About the Graphing Function

The large 95 × 63 dot display of the unit provides you with the capability to graph the following:

Rectangular coordinates
Polar coordinates
Parametrics
Inequalities
Integrations
Probability distributions
Single-variable statistics
Paired-variable statistics

These graphs can be produced using manual input or by programs.
You should enter the COMP, SD, REG, MAT or GRAPH Mode for drawing graphs. Here, we will start our explanation of graph drawing using the COMP Mode.

■Specifying the Range of a Graph

Before you draw a graph, you must first use the Range Parameter Screen to specify the range parameters of the graph.

• To display the Range Parameter Screen

Rectangular Coordinate Range Screen

[Range]

Xmin — minimum value of *x*-coordinate
Xmax — maximum value of *x*-coordinate
Xscl — scale of *x*-coordinate
Ymin — minimum value of *y*-coordinate
Ymax — maximum value of *y*-coordinate
Yscl — scale of *y*-coordinate

```
Range
Xmin:-5.
 max:5.
 scl:2.
Ymin:-10
 max:10.
 scl:5.
INIT TRG
```


Polar Coordinate Range Screen

[Range]

T, θ min — minimum value of T/θ
T, θ max — maximum value of T/θ
T, θ pitch — pitch of T/θ

```
Range
T, θ
 min:0.
 max:360.
 ptch:3.6

INIT TRG
```

• To specify range parameters

Example To specify the following range parameters

Xmin	0
Xmax	5
Xscl	1
Ymin	−5
Ymax	15
Yscl	5
T, θ min	0
T, θ max	4π
T, θ ptch	π ÷ 36

① [0] [EXE]

```
Range
Xmin:0
 max:5.
 scl:2.
Ymin:-10.
 max:10.
 scl:5.
INIT TRG
```

② [EXE]

```
Range
Xmin:0
 max:5.
 scl:2.
Ymin:-10.
 max:10.
 scl:5.
INIT TRG
```

③ [1] [EXE]

```
Range
Xmin:0
 max:5.
 scl:1
Ymin:-10.
 max:10.
 scl:5.
INIT TRG
```

④ [▶] [5] [EXE]

```
Range
Xmin:0
 max:5.
 scl:1
Ymin:-5
 max:10.
 scl:5.
INIT TRG
```

⑤ ▶ 5 EXE

```
Range
Xmin:0
 max:5.
 scl:1
Ymin:-5
 max:15
 scl:5.
INIT TRG
```

⑥ EXE

```
Range
T, θ
 min:0.
 max:360.
ptch:3.6
INIT TRG
```

⑦ EXE

```
Range
T, θ
 min:0.
 max:360.
ptch:3.6
INIT TRG
```

⑧ 4 SHIFT π EXE

```
Range
T, θ
 min:0.
 max:4π
ptch:3.6
INIT TRG
```

⑨ SHIFT π ÷ 3 6

```
Range
T, θ
 min:0.
 max:4π
ptch:π÷36_
INIT TRG
```

Now if you press Range, EXIT, or SHIFT QUIT, the Range Parameter Display is cleared. Next, you can use Range to confirm that your parameters are correct.

⑩ Range

```
Range
Xmin:0.
 max:5.
 scl:1.
Ymin:-5.
 max:15.
 scl:5.
INIT TRG
```

⑪ Range

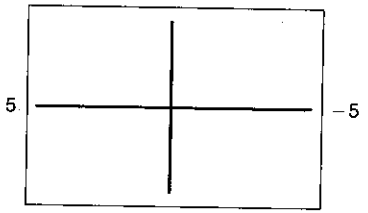
```
Range
T, θ
 min:0.
 max:12.5663706
ptch:0.087266462
INIT TRG
```

Note that the π and division operations we entered above have been automatically converted to the correct values.

- You can set range parameters within the range of −9.9999E+97 to 9.99999E+97.

- Input values can have up to nine significant digits. Values less than 10^{-2} and greater than 10^{7} are displayed with a 6-digit mantissa (including the negative sign) and a 2-digit exponent.
- The only input that is valid for range parameter input are numbers from 0 through 9, decimal points, EXP, (−), ◀, ▶, ▲, ▼, +, −, ×, ÷ and π. You can also use Range, EXIT, SHIFT QUIT, but no other key operation is valid. Note that negative values are indicated using (−) or −.
- You cannot specify 0 for Xscl or Yscl.
- Do not specify the same value for the minimum and maximum.
- If you input an illegal value, the previous parameter is retained without change.
- If a minimum is greater than a maximum parameter, the axis is inverted.

Example **Xmin :5**
Xmax : −5



- Note that when you press EXE to input a parameter, anything that was previously located to the right of the cursor position is not input.

Example

```
Range
Xmin:-25.
 max:25.
```

▶

```
Range
Xmin:-25.
 max:25.
```

3

```
Range
Xmin:-35.
 max:25.
```

EXE

```
Range
Xmin:-3
 max:25.
```

- You can input range parameters as expressions (such as 2π).
- When a range setting that does not allow display of the axes is used, the scale for the y-axis is indicated on either the left or right edge of the display, while that for the x-axis is indicated on either the top or bottom edge.
- When range values are changed, the graph display is cleared and the newly set axes only are displayed.

- Range setting may cause irregular scale spacing.
- If the range is set too wide, the graph produced may not fit on the display.
- The point of deflection sometimes exceeds the capabilities of the display with graphs that change drastically as they approach the point of deflection.
- A range that is too small can cause an Ma ERROR.

■Initializing the Range Parameter Display Settings

There are two methods that you can use to initialize the Range Parameter Display settings.

● [Range] [F1](INIT)

```
Range
Xmin:-4.7
 max:4.7
 scl:1.
Ymin:-3.1
 max:3.1
 scl:1.
INIT TRG
```

● [Range] [F2](TRG)

This operation performs initialization in accordance with the current unit of angular measurement mode (Deg, Rad, or Gra). This initialization operation is helpful when drawing trigonometric graphs.

Deg Mode

```
Range
Xmin:-360.
 max:360.
 scl:180.
Ymin:-1.6
 max:1.6
 scl:0.5
INIT TRG
```

Rad Mode

```
Range
Xmin:-6.28318531
 max:6.28318531
 scl:3.14159265
```

Gra Mode

```
Range
Xmin:-400.
 max:400.
 scl:200.
```

T, θ min, T, θ max, and t, θ pitch are not affected when you press [F2](TRG).

● **To specify range parameters within a program**

Use the following format to specify range parameters in a program.

Range (value of Xmin), (value of Xmax), (value of Xscl), (value of Ymin), (value of Ymax), (value of Yscl), (value of T, θmin), (value of T, θmax), (value of T, θpitch)

7-2 Rectangular Coordinate Graphs

You can use the unit to draw rectangular coordinate graphs after you specify the REC Mode. When drawing rectangular coordinate graphs, remember that the unit uses value memories **X** and **Y** to store values. Do not use these memories for storage if you plan to draw rectangular coordinate graphs.

■Graphing Built-in Scientific Functions

The following is a list of the built-in scientific functions that you can graph.

•sin$x$	•cos$x$	•tan$x$	•sin^{-1}x	•cos^{-1}x	•tan^{-1}x
•sinh$x$	•cosh$x$	•tanh$x$	•sinh^{-1}x	•cosh^{-1}x	•tanh^{-1}x
•$\sqrt{x}$	•x^2	•log$x$	•ln$x$	•10^x	•e^x
•x^{-1}	•$\sqrt[3]{x}$				

Use the RUN/COMP Mode to draw rectangular coordinate graphs. Do not use the BASE or EQUA Mode. When you graph a built-in function, the range parameters are set by the unit automatically.

● **To check the current mode**

[MODE] [DISP]

● **To enter the correct mode**

[MENU](COMP)[EXE](or [1])

```
RUN / COMP
```

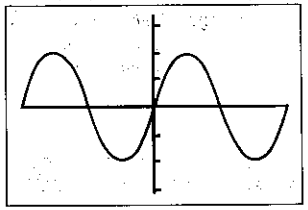
[SHIFT] [SETUP] [F1](REC)

```
▶GRAPH TYPE:REC
```

[EXIT]

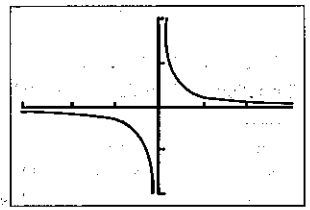
• To graph the sine function

[Graph] [sin] [EXE]



• To graph the $y = {}^{1}/_{x}$ function

[Graph] [SHIFT] [x^{-1}] [EXE]



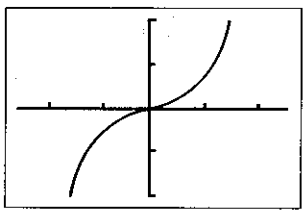
■Overdrawing Built-in Function Graphs

You can draw two or more built-in function graphs on the same screen. The range of first graph is set automatically, and the same range is applied for subsequent graphs. The important thing to note in the following example is the use of [X,θ,T]. By pressing [X,θ,T] before [EXE] to graph the second function, you are telling the unit to leave the previously drawn graphs on the display. If you do not press [X,θ,T], the unit will clear the graphic display automatically and graph only the last function you entered.

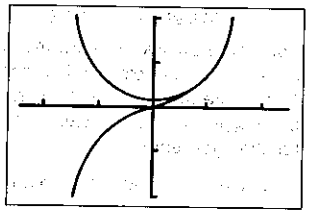
• To overdraw graphs

Example **To graph $y = \sinh x$ and overdraw it with $y = \cosh x$:**

[SHIFT] [F5] (Cls) [EXE]
[Graph] [SHIFT] [MATH] [F1] (HYP)
[F1] (snh) [EXE]



[Graph] [F2] (csh) [X,θ,T] [EXE]



Note
You cannot use built-in function graphs in multistatements (page 30) and programming (page 202).

■Graphing Manually Entered Functions

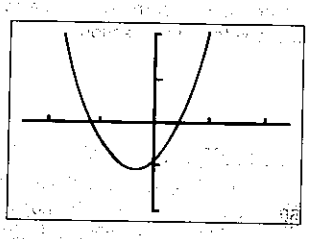
You can graph manually entered functions by simply pressing [Graph] and then entering the function. Remember that you also have to specify range parameters (page 137).

• To graph a manually entered function

Example **To graph $y = 2x^2 + 3x - 4$ using the following range parameters:**

```
Range
Xmin:-5.
 max:5.
 scl:2.
Ymin:-10.
 max:10.
 scl:5.
INIT TRG
```

[SHIFT] [F5] (Cls) [EXE]
[Graph] [2] [X,θ,T] [x^2] [+] [3] [X,θ,T] [−]
[4] [EXE]



■Overdrawing Manually Input Graphs

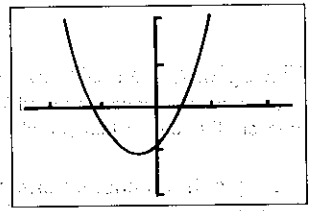
You can draw two or more manually input graphs on the same screen. This makes it possible to find points of intersection and solutions at a glance.
Again note the use of [X,θ,T] before [EXE] when graphing the second function. If you do not press [X,θ,T], the unit will clear the graphic display automatically and graph only the last function you entered

•You can also input value memory name X by pressing [ALPHA][X].

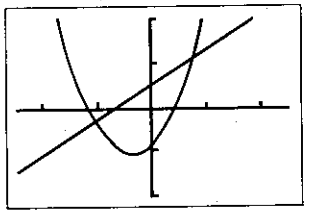
• To overdraw manually entered graphs

Example To graph $y=2x^2+3x-4$ and overdraw it with $y=2x+3$:

[SHIFT][F5](Cls)[EXE]
[Graph][2][X,θ,T][x^2][+][3][X,θ,T][−]
[4][EXE]



[Graph][2][X,θ,T][+][3][EXE]



Later you will learn how to use the Trace Function (page 170) to find out the values at the points of intersection.

■Specifying the Value Range

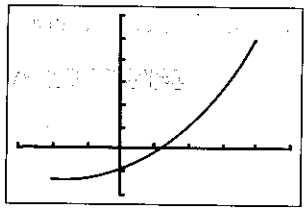
When graphing a function with the format "y=function", you can specify the maximum and minimum values to be applied. Use the following format.

[Graph] function [SHIFT][)][ALPHA][(] Xmin [SHIFT][)] Xmax [ALPHA][)][EXE]

Example To graph $y=x^2+3x-5$ for the range $-2 \leqq x \leqq 4$:

```
Range
Xmin:-3.
 max:5.
 scl:1.
Ymin:-10.
 max:30.
 scl:5.
INIT TRG
```

[SHIFT][F5](Cls)[EXE]
[Graph][X,θ,T][x^2][+][3][X,θ,T][−]
[5][SHIFT][)][ALPHA][(][(−)][2]
[SHIFT][)][4][ALPHA][)][EXE]



7-3 Polar Coordinate Graphs

After you change from the REC Mode to the POL Mode, you can use the unit to draw polar coordinate graphs. When you graph a built-in function, the range parameters are set by the unit automatically. The functions that can be graphed in the POL Mode are those that fit the following format:

$r=\mathbf{f}(\theta)$

Note that you should specify **rads** as the unit of angular measurement when graphing polar coordinate graphs. When drawing polar coordinate graphs, remember that the unit uses value memories **r** and θ to store values. Do not use these memories for storage if you plan to draw polar coordinate graphs.

■Graphing Built-In Scientific Functions

Use the RUN/COMP Mode to draw polar coordinate graphs. Do not use the BASE or EQUA Mode. When you graph a built-in function, the range parameters are set by the unit automatically.
The following is a list of the built-in scientific functions that you can graph using polar coordinates.

$\sin\theta$	$\cos\theta$	$\tan\theta$	$\sin^{-1}\theta$	$\cos^{-1}\theta$	$\tan^{-1}\theta$			
$\sinh\theta$	$\cosh\theta$	$\tanh\theta$	$\sinh^{-1}\theta$	$\cosh^{-1}\theta$	$\tanh^{-1}\theta$			
$\sqrt{\theta}$	θ^2	$\log\theta$	$\ln\theta$	10^θ	e^θ	θ^{-1}	$\sqrt[3]{\theta}$	

• **To check the current mode**

[M] Disp

• **To enter the correct mode**

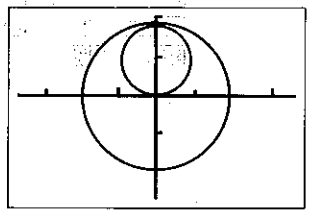
[SHIFT] (COMP) [EXE] (or [1])
[SHIFT] [DRG] [F2] (Rad) [EXE]
[SHIFT] [SET UP] [F2] (POL)

▶GRAPH TYPE:POL

[EXIT]

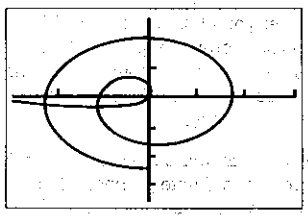
Example 1 To graph tanh θ:

[Graph] [SHIFT] [MATH] [F1] (HYP) [F3] (tnh) [EXE]



Example 2 To graph ln θ:

[Graph] [ln] [EXE]



■Graphing Manually Entered Functions

You can graph manually entered functions by simply pressing [Graph] and then entering the function. Manually entered functions must have the following format:

Graph r=[θ function]

Remember that you also have to specify range parameters (page 137).

• **To graph a manually entered function**

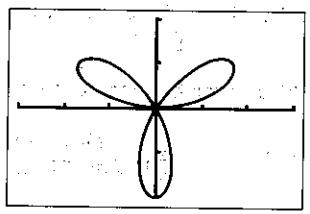
Example To graph $r=2\sin 3\theta$ using the following range parameters:

```
Range
Xmin:-3.
 max:3.
 scl:1.
Ymin:-2.
 max:2.
 scl:1.
INIT TRG
```

```
Range
T, θ
 min:0.
 max:π.
ptch:π÷36

INIT TRG
```

[SHIFT] [F5] (Cls) [EXE]
[Graph] [2] [sin] [3] [X,θ,T] [EXE]



Important

If the difference between the minimum and maximum values you set for the pitch of T or θ is too great, your graph will be too rough. If the difference is too small, drawing of the graph will take a very long time.

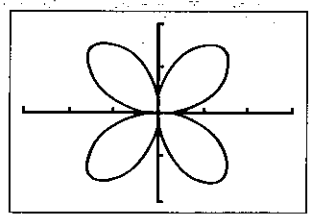
■Specifying the Value Range

When graphing a polar coordinate function, you can specify the maximum and minimum values to be applied. Use the following format.

[Graph] **function** [SHIFT] [,] [ALPHA] [(] **θmin** [SHIFT] [,] **θmax** [ALPHA] [)] [EXE]

Example To graph $r = 4\sin\theta\cos\theta$ for the range $-\pi \leqq \theta \leqq \pi$:

[SHIFT] [F5] (Cls) [EXE]
[Graph] [4] [sin] [X,θ,T] [cos] [X,θ,T] [SHIFT] [,]
[ALPHA] [(] [(−)] [SHIFT] [π] [SHIFT] [,] [SHIFT] [π]
[ALPHA] [)] [EXE]



7-4 Parametric Graphs

To draw parametric graphs, first change to the PRM Mode. Do not try to use the BASE or EQUA Mode for graphing. The functions that can be graphed in the PRM Mode are those that fit the following format:

(X, Y) = (f(T), g(T))

When drawing parametric graphs, remember that the unit uses value memories **X**, **Y** and **T** to store values. Do not use these memories for storage if you plan to draw parametric graphs.

- **To check the current mode**

[MODE] Disp

- **To enter the correct mode**

[MENU] (COMP) [EXE] (or [1])
[SHIFT] [SETUP] [F3] (PRM)

```
▶GRAPH  TYPE:PRM
```

[EXIT]

- **To graph a parametric equation**

Example To graph the following functions:
$x = 7\cos T - 2\cos 3.5T$
$y = 7\sin T - 2\sin 3.5T$

Use the following range parameters.

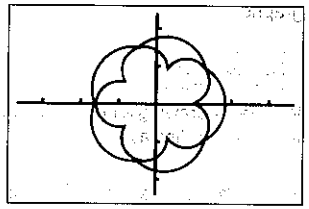
```
Range
Xmin:−18.
 max:18.
 scl:5.
Ymin:−12.
 max:12.
 scl:5.
INIT TRG
```



```
Range
T, θ
 min:0.
 max:4π.
 ptch:π÷36

INIT TRG
```

[SHIFT] [F5] (Cls) [EXE]
[SHIFT] [DRG] [F2] (Rad) [EXE]
[Graph] [7] [cos] [X,θ,T] [−] [2] [cos] [3] [•] [5]
[X,θ,T] [SHIFT] [,] [7] [sin] [X,θ,T] [−] [2] [sin]
[3] [•] [5] [X,θ,T] [)] [EXE]



Important

If the difference between the minimum and maximum values you set for the pitch of T or θ is too great, your graph will be too rough. If the difference is too small, drawing of the graph will take a very long time.

■Specifying the Value Range

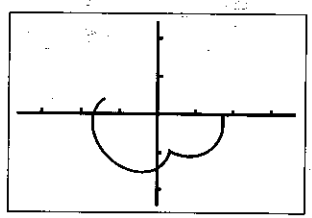
When graphing a parametric function, you can specify the maximum and minimum values to be applied. Use the following format.

[Graph] **function** [SHIFT] [,] [ALPHA] [(] **Tmin** [SHIFT] [,] **Tmax** [ALPHA] [)] [EXE]

Example To graph the following functions:
$x = 7\cos T - 2\cos 3.5T$
$y = 7\sin T - 2\sin 3.5T$

Use the following range:
$\pi \leqq T \leqq 2\pi$

[SHIFT] [F5] (Cls) [EXE]
[SHIFT] [DRG] [F2] (Rad) [EXE]
[Graph] [7] [cos] [X,θ,T] [−] [2] [cos] [3] [•] [5]
[X,θ,T] [SHIFT] [,] [7] [sin] [X,θ,T] [−] [2] [sin]
[3] [•] [5] [X,θ,T] [)] [SHIFT] [,] [ALPHA] [(]
[SHIFT] [π] [SHIFT] [,] [2] [SHIFT] [π] [ALPHA] [)]
[EXE]



7-5 Inequality Graphs

To draw inequality graphs, first change to the INEQ Mode. Do not try to use the BASE or EQUA Mode for graphing. The functions that can be graphed in the INEQ Mode are those that fit one of the following formats:

$Y > f(x)$ $Y \geqq f(x)$
$Y < f(x)$ $Y \leqq f(x)$

When drawing inequality graphs, remember that the unit uses value memories **X** and **Y** to store values. Do not use these memories for storage if you plan to draw inequality graphs.

Important

Whenever drawing a new inequality graph, you should always start out with [SHIFT][F5](Cls)[EXE] to clear the display.

• To check the current mode

[MDisp]

• To enter the correct mode

[MENU](COMP)[EXE](or [1])
[SHIFT][SETUP][F4](INQ)

[EXIT]

▶GRAPH TYPE: INEQ

When you press the [Graph] key in the INEQ Mode, the display shown here appears.

Y> Y< Y≥ Y≤
[F1] [F2] [F3] [F4]

Use the function keys to input the inequality you are graphing.

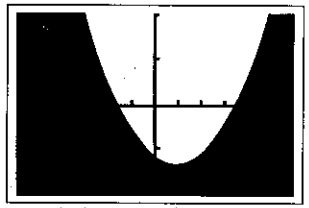
Function Key	Inputs
[F1]	Y>
[F2]	Y<
[F3]	Y≧
[F4]	Y≦

• To graph an inequality

Example **To graph $y<x^2-2x-6$ using the following range parameters:**

```
Range
Xmin:-6.
 max:6.
 scl:1.
Ymin:-10.
 max:10.
 scl:5.
INIT TRG
```

[SHIFT][F5](Cls)[EXE]
[Graph][F2](Y<)[X,θ,T][x^2][−]
[2][X,θ,T][−][6][EXE]



■Overdrawing Inequality Graphs

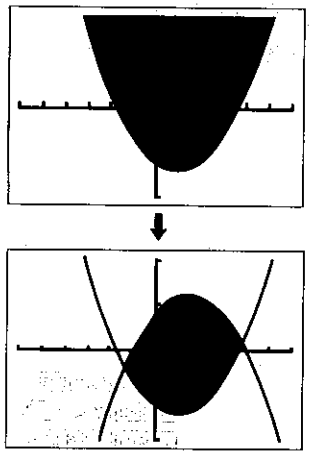
If you draw two or more inequality function graphs on the same screen, the area containing values that satisfy both functions is filled in.
In the following input sequence we will input two functions with a single operation. Note the [SHIFT][↵] operation that separates the two functions.

• To overdraw inequality graphs

Example **To graph $y>x^2-2x-6$ and overdraw it with $y<-x^2+3x+4$ using the following range parameters:**

```
Range
Xmin:-6.
 max:6.
 scl:1.
Ymin:-10.
 max:10.
 scl:5.
INIT TRG
```

SHIFT F5 (Cls) EXE
Graph F1 (Y>) X,θ,T x^2 −
2 X,θ,T − 6 SHIFT ↵
F2 (Y<) (−) X,θ,T x^2 +
3 X,θ,T + 4 EXE



■Specifying the Value Range

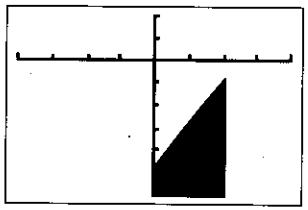
When drawing inequality graphs, you can specify the maximum and minimum values to be applied. Use the following format.

Graph **[Fn] (inequality)** SHIFT , ALPHA [**Xmin** SHIFT , **Xmax** ALPHA] EXE
(n = 1 to 4)

Example **To graph $y \leqq 2x-5$ using the range $0 \leqq x \leqq 2$, and the following range parameters:**

```
Range
Xmin:-4.
 max:4.
 scl:1.
Ymin:-6.
 max:2.
 scl:1.
INIT TRG
```

SHIFT F5 (Cls) EXE
Graph F4 (Y≤) 2 X,θ,T
− 5 SHIFT , ALPHA [
0 SHIFT , 2 ALPHA]
EXE



7-6 Integration Graphs

To draw integration graphs, you press SHIFT G/dx, enter the function, and then press EXE. The unit produces the graph on the display with the solution range painted in.

Important

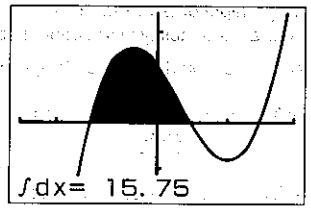
- Whenever drawing a new integration graph, you should always start out with SHIFT F5 (Cls) EXE to clear the display.
- Do not try to use the BASE, EQUA, or GRAPH Mode for integration graphing.

• To graph an integral

Example **To graph $\int_{-2}^{1}(x+2)(x-1)(x-3)dx$ using the following range parameters:**

```
Range
Xmin:-4.
 max:4.
 scl:1.
Ymin:-8.
 max:12.
 scl:5.
INIT TRG
```

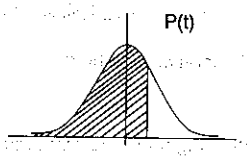
SHIFT F5 (Cls) EXE
SHIFT G/dx (X,θ,T + 2) (X,θ,T
− 1) (X,θ,T − 3)
SHIFT , (−) 2 SHIFT , 1 SHIFT ,
5 EXE



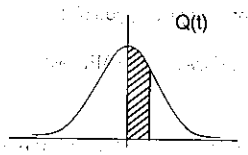
Note that you can also include the integral graph operation within programs.

7-7 Probability Distribution Graphs

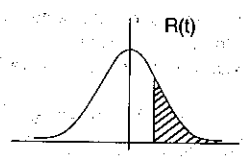
The unit calculates the three types of probability normal distribution shown below, along with normalized variate t(x). It also produces a probability density function graph (standard normal distribution curve) for the normal distribution.



$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{t} e^{-\frac{t^2}{2}}\,dt$$



$$\frac{1}{\sqrt{2\pi}}\int_{0}^{t} e^{-\frac{t^2}{2}}\,dt$$



$$\frac{1}{\sqrt{2\pi}}\int_{t}^{+\infty} e^{-\frac{t^2}{2}}\,dt$$

t(x)

$$t=\frac{x-\bar{x}}{\sigma n}$$

Once you input a value that represents the normalized variate t(x) for one of the probabilities P(t), Q(t) and R(t), the unit produces the corresponding standard normal distribution curve. At this time, the probability calculation result appears on the display, with the calculation range highlighted in the graph.

To draw probability distribution graphs, the unit should be in the SD Mode and REC Mode.

•Note that you do not need to specify range parameters with probability distribution graphs.

• To check the current mode

[MODE](Disp)

• To enter the correct mode

[MENU](SD)[EXE](or [3])

```
RUN / SD
```

[SHIFT][SETUP][F1](REC)

```
▶GRAPH TYPE:REC
```

[EXIT]

When you press the [F6](PQR) key, the display shown here appears.

```
P( Q( R( t(
```

[F1] [F2] [F3] [F4]

Use the function keys to input the probability distribution you are graphing.

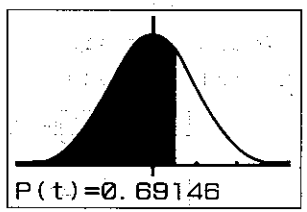
[F1](P( )..... Draws standard normal distribution curve and calculates probability P(t)
[F2](Q( ) ..... Draws standard normal distribution curve and calculates probability Q(t)
[F3](R( )..... Draws standard normal distribution curve and calculates probability R(t)
[F4](t( )..... Calculates normalized variate t(x)

•You cannot draw a graph for the normalized variate function t(x).

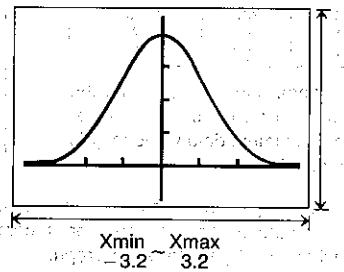
• To graph a probability distribution

Example **To graph P(0.5)**

[SHIFT][F5](Cls)[EXE]
[Graph][F6](PQR)[F1](P( )[0][•][5]
[)][EXE]



*The following shows the parameters that the unit uses for the probability distribution graph.



7-8 Single-Variable Statistical Graphs

To draw single-variable statistical graphs, you must use the SD Mode and the statistical graph DRAW Mode. The unit lets you draw bar graphs, line graphs and normal distribution curves using data you input.

• To check the current mode

[MODE] Disp

• To enter the correct mode

[MENU](SD)[EXE](or [3])
[SHIFT][SETUP]
[▼][▼][▼]
[F1](DRW)
[EXIT]

```
RUN / SD
```

```
▶STAT GRAPH:DRAW
```

• To draw a bar graph

Example **To draw a bar graph of the following data:**

Rank	Value	Frequency
1	0	1
2	10	3
3	20	2
4	30	2
5	40	3
6	50	5
7	60	6
8	70	8
9	80	15
10	90	9
11	100	2

First, specify the range parameters. Since the maximum data value for x is 100, we will set Xmax as 110. The maximum data value for y is 15, so set Ymax as 20.

```
Range
Xmin:0.
 max:110.
 scl:10.
Ymin:0.
 max:20.
 scl:2.
INIT TRG
```

Next, specify the number of bars by increasing the number of value memories. Since we have 11 ranks, we should increase the number of memories by 11. If you skip this step, an error occurs when you try to draw the graph.

[SHIFT][Defm][1][1][EXE]

```
Prg:    0 Mem:  39
F-M:    0 Mat:   0
Grp:    0 SD :   0
          REG:   0
          Sim:   0
          Pol:   0
 3912 Bytes Free
DT CL  :  DEV Σ  POR
```


Now clear the statistical memory.

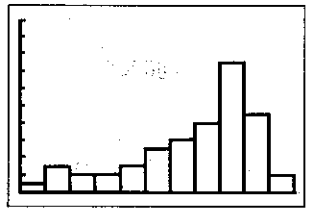
[SHIFT][CLR][F2](Scl)[EXE]

Input the data. For full details on the techniques you can use to input statistical data, see page 79.

[EXIT]**0**[F1](DT)**10**[F1](DT)[F1](DT)[F1](DT)**20**[F1](DT)[F1](DT)
30[F1](DT)[F1](DT)**40**[F1](DT)[F1](DT)[F1](DT)
50[F3](;)**5**[F1](DT)**60**[F3](;)**6**[F1](DT)**70**[F3](;)**8**[F1](DT)
80[F3](;)**15**[F1](DT)**90**[F3](;)**9**[F1](DT)**100**[F1](DT)[F1](DT)

Now draw the graph.

[Graph][EXE]



• Find the mode (Mod) on a graph

You can find the mode (Mod) on a bar graph using the pointer. Note, however that you can only perform this operation immediately after a bar graph is drawn on the display. To find the mode immediately after drawing the above bar graph.

[G↔T]

```
DT CL  :  DEV Σ  POR
```

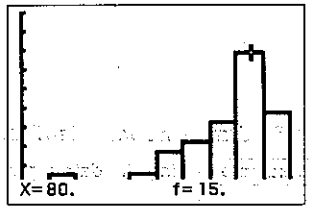
[F4]

```
x̄  xσn  xσn-1  Mod
```

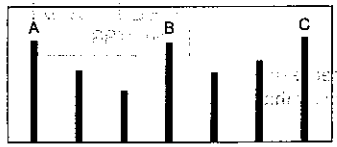
[F4]

[F4](DEV)

[F4](Mod)



- The mode is indicated by the pointer flashing at the highest point on the graph. The values at the bottom of the graph show the data item [X] along with is frequency [f].
- In the case of multimodal distribution, the pointer will be located at the top of the bar that is farthest to the right. In the following graph, bars A, B, and C have the same frequency, so the pointer is located at the top of C because it is farthest to the right.



Use the following procedure when using the STO Mode in the statistical data (STAT DATA) Mode.

G⇔T

DT EDIT : DEV Σ POP

F4

F4(DEV)

$\bar{x}$ $x\sigma n$ $x\sigma n{-}1$ ▽

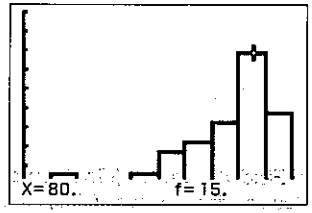
F4

F4(▽)

Mod Med Max Min

F1

F1(Mod)

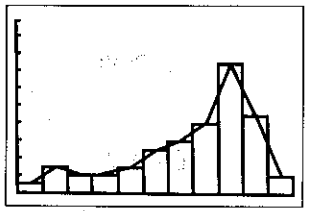


•See page 84 for information on determining Med, Max, and Min.

• To superimpose a line graph on a bar graph

While a bar graph is displayed, perform the following key operation.

Graph SHIFT F4(Line) EXE



• To draw a normal distribution curve

Example **Using the data input above, with the following range parameters:**

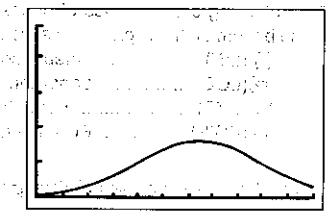
```
Range
Xmin:0.
 max:110.
 scl:10.
Ymin:0.
 max:0.05
 scl:0.01
INIT TRG
```

This change in range parameters is necessary because the y values are so much smaller than the x values.

Draw the graph.

Graph SHIFT F4(Line) 1 EXE

Inputting the number 1 causes a normal distribution curve to be drawn.



Notes

- Be sure to expand the number of value memories to match the number of bars in a bar graph.
- If you change the number of value memories while you are inputting data, you will not be able to draw a graph correctly.
- If you input a value that is outside the minimum and maximum ranges you specify for the range parameters, the data is stored in statistical memory but not in graph memory.
- If you input data that is greater than the maximum you specify for the y-axis, the bar is drawn to the upper limit of the display, and the points outside the range cannot be connected.
- The following is the formula the unit uses to draw the normal distribution curve.

$$y=\frac{1}{\sqrt{2\pi}x\sigma n}e^{-\frac{(x-\bar{x})^2}{2x\sigma n^2}}$$

- For range parameter settings, Xmin must be less than Xmax.
- The message "done" appears on the display to indicate that drawing of a bar or line graph is complete.

7-9 Paired-Variable Statistical Graphs

To draw paired-variable statistical graphs, you must use the REG Mode and the statistical graph DRAW Mode. The unit draws graphs using data you input.

• To check the current mode

M Disp

• To enter the correct mode

MENU(REG) EXE(or 4)

SHIFT SETUP F1(REC)

▶GRAPH TYPE:REC

▼▼▼F1(DRW)

▶STAT GRAPH:DRAW

▼

▶REG MODEL :LIN

LIN LOG EXP PWR

F1 F2 F3 F4

The following are the types of operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

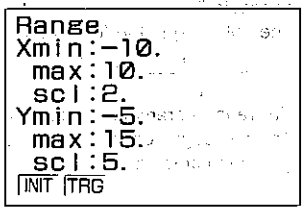
- [F1](LIN) ..... Linear regression line drawing (LIN Mode)
- [F2](LOG) ..... Logarithmic regression curve drawing (LOG Mode)
- [F3](EXP) ..... Exponential regression curve drawing (EXP Mode)
- [F4](PWR) ..... Power regression curve drawing (PWR Mode)

• To draw a paired-variable graph

Example **To draw a graph of the following data:**

xi	*yi*
−9	−2
−5	−1
−3	2
1	3
4	5
7	8

First, specify the range parameters as shown right.



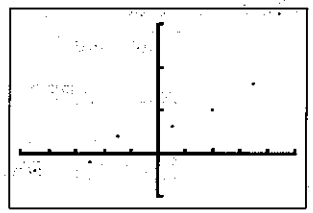
Now clear the statistical memory.

[EXIT] [SHIFT] [CLR] [F2](Scl) [EXE]

Input the data. For full details on the techniques you can use to input statistical data, see page 86.

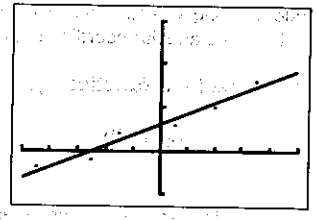
[EXIT]

[(−)] [9] [F3](,) [(−)] [2] [F1](DT)
[(−)] [5] [F3](,) [(−)] [1] [F1](DT)
[(−)] [3] [F3](,) [2] [F1](DT)
[1] [F3](,) [3] [F1](DT)
[4] [F3](,) [5] [F1](DT)
[7] [F3](,) [8] [F1](DT)



Now draw the graph.

[Graph] [SHIFT] [F4](Line) [1] [EXE]



Notes

- A point is not plotted if a set of data is outside the range parameter values you specify.
- The following key operation causes an error (Ma ERROR) if no paired-variable statistical data is present in memory.
  [Graph] [SHIFT] [F4](Line) [1] [EXE]
- For range parameter settings, Xmin must be less than Xmax.

7-10 Storing Functions in Memory

You can store up to 20 functions and expressions in memory for later recall, editing, or graphing. Rectangular coordinate, polar coordinate, and parametric functions, as well as inequalities can all be stored in memory. Note that the total amount of memory used for storage of functions cannot exceed 127 bytes.

■ To Access the Graphic Function Memory

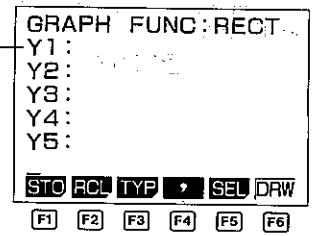
Highlight the **GRAPH** icon on the Main Menu.

[MENU]

[▲] [▼] [◀] [▶]

Press [EXE] or [6] to display the GRAPH Mode.

[EXE] or [6]



Memory locations

The following are the types of operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

- [F1](STO) ..... Stores the function into memory
- [F2](RCL) ..... Recalls a function from memory
- [F3](TYP) ..... Specifies a type for a stored function
- [F4](,) ..... Inputs a comma between parametric functions
- [F5](SEL) ..... Selects whether or not a graph should be drawn
- [F6](DRW) ..... Draws a graph for a stored function

■ Function Types

Before storing a function into memory, be sure to first use the following procedure to specify its type (rectangular coordinate, polar coordinate, parametric, inequality).

• To specify a function type

[F3](TYP)

```
REC POL PRM INQ
F1  F2  F3  F4
```

The following are the function types that can be selected from the function menu at the bottom of the display. Press the function key below the type you want to specify.

- [F1](REC) ..... Rectangular coordinate
- [F2](POL) ..... Polar coordinate
- [F3](PRM) ..... Parametric
- [F4](INQ) ..... Inequality

• To store a rectangular coordinate function

Example **To store the following rectangular coordinate graph function in memory location Y2:**

$y = 2x^2 - 5$

First specify the function type as rectangular coordinate.

[F3](TYP)[F1](REC)

Input the function.

[2][X,θ,T][x^2][−][5]

```
2X²−5
STO RCL TYP ▸ SEL DRW
F1
```

The currently specified memory location is highlighted.

[F1](STO)

```
GRAPH FUNC:RECT
Y1:
Y2:
Y3:
Y4:
Y5:
2X²−5
STO      SELECT [↓] [↑] SET
```

Move to the memory location where you want to store the function.

[▼]

```
GRAPH FUNC:RECT
Y1:
Y2:
Y3:
Y4:
Y5:
2X²−5
STO      SELECT [↓] [↑] SET
F6
```


Store the function into memory.

[F6](SET)

```
GRAPH FUNC:RECT
Y1:
Y2=2X²−5
Y3:
Y4:
Y5:
STO RCL TYP ▸ SEL DRW
```

• To store a polar coordinate function

Example **To store the following polar coordinate graph function in memory location *r*3:**

$r = 5 \sin 3\theta$

First specify the function type as polar coordinate.

[F3](TYP)[F2](POL)

Input the function.

[5][sin][3][X,θ,T]

```
5sin 3θ
STO RCL TYP ▸ SEL DRW
F1
```

The currently specified memory location is highlighted.

[F1](STO)

```
GRAPH FUNC:POL
r1:
Y2=2X²−5
r3:
r4:
r5:
5sin 3θ
STO      SELECT [↓] [↑] SET
```

Move to the memory location where you want to store the function.

[▼][▼]

```
GRAPH FUNC:POL
r1:
Y2=2X²−5
r3:
r4:
r5:
5sin 3θ
STO      SELECT [↓] [↑] SET
F6
```

Store the function into memory.

[F6](SET)

```
GRAPH FUNC:POL
r1:
Y2=2X²−5
r3=5sin 3θ
r4:
r5:
STO RCL TYP ▸ SEL DRW
```

• To store parametric functions

Example **To store the following parametric functions in memory location f4:**
$x = 3 \sin T$
$y = 3 \cos T$

First specify the function type as parametric.

F3(TYP)F3(PRM)

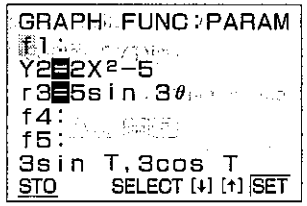
Input the functions.

3 sin X,θ,T F4(,)
3 cos X,θ,T

F1

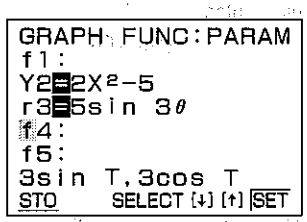
The currently specified memory location is highlighted.

F1(STO)



Move to the memory location where you want to store the functions.

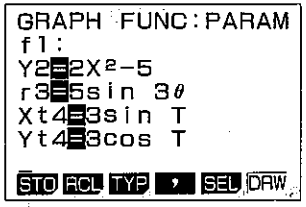
▼▼▼



F6

Store the functions into memory.

F6(SET)



• To store an inequality

Example **To store the following inequality in graphic function memory location Y5:**
$y < x^2 - 2x - 6$

First specify the function type as inequality.

F3(TYP)F4(INQ)

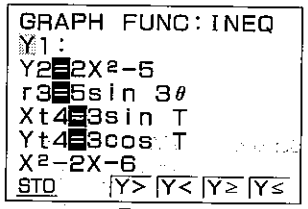
Input the function.

X,θ,T x² − 2 X,θ,T − 6

F1

The currently specified memory location is highlighted.

F1(STO)



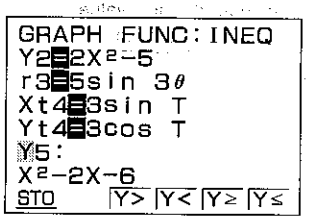
F3 F4 F5 F6

The following are the inequality types that can be selected from the function menu at the bottom of the display. Press the function key below the type you want to specify.

F3(Y>) ..... $y > f(x)$
F4(Y<) ..... $y < f(x)$
F5(Y≥) ..... $y \geq f(x)$
F6(Y≤) ..... $y \leq f(x)$

Move to the memory location where you want to store the function.

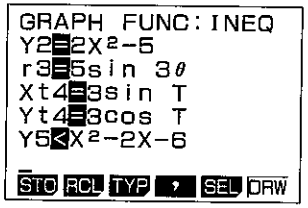
▼▼▼▼



F4

Store the function into memory.

F4(Y<)



■Editing Functions in Memory

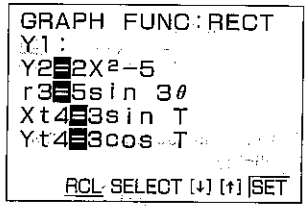
Use the following procedures to modify and delete functions that are stored in memory.

• To modify a function in memory

Example **To change the function in memory location Y2 ($y=2x^2-5$) to $y=2x^2-3$:**

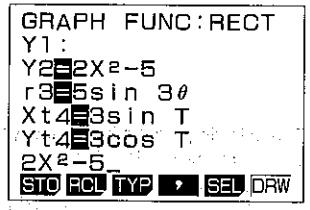
Recall the function.

[F2](RCL)



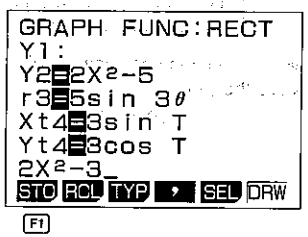
Scroll down to Y2.

▼[F6](SET)

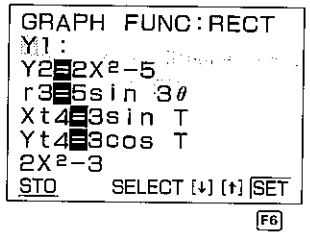


Move the cursor to the location of the change and then input the new value.

◀[3]

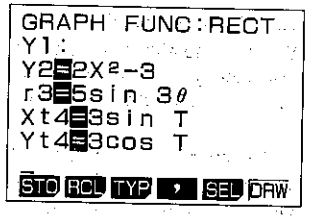


[F1](STO)



Store the new function into memory.

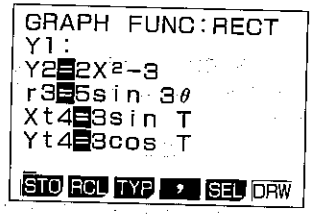
▼[F6](SET)



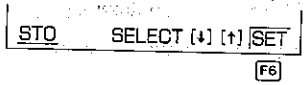
• To delete a function from memory

Example **To delete the function in memory location Y2:**

Display the list of functions in memory.

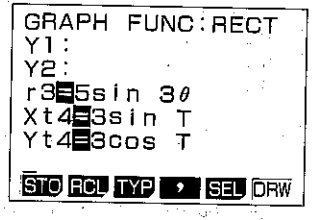


[F1](STO)



Scroll down to Y2.
Delete the function located at Y2.

▼[F6](SET)



■Drawing Graphs from Memory

You can use either of the two following methods to draw graphs from memory.
- Drawing graphs from specific functions in memory
- Overlaying graphs for all the functions in memory

• To specify the overlaying method

When drawing overlaid graphs, you can set up the unit to draw them one-by-one or simultaneously. Use the following procedure to specify which method you want to use.

[SHIFT] [SETUP] [▼] [▼]

```
▶SIML GRAPH:ON
 ON OFF
  F1  F2
```

Press [F1](ON) to specify that graphs should be drawn simultaneously. Press [F2](OFF) to specify that graphs should be drawn one-by-one, in graphic function memory location sequence.

[EXIT]

• To draw graphs from specific functions in memory

Example 1 **To draw a graph of the function in memory location Y2 ($y=2x^2-3$):**

Use the following range parameters.

```
Range
Xmin:-5.
 max:5.
 scl:1.
Ymin:-5.
 max:5.
 scl:1.
INIT TRG
```

[F5](SEL)

```
GRAPH FUNC:RECT
Y1:
Y2=2X²-3
r3=5sin 3θ
Xt4=3sin T
Yt4=3cos T
SET CAN      DRW
      F2
```

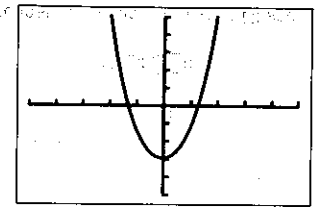
Scroll through the graphs, and cancel those that you do not want drawn. Only the graphs whose equal signs are highlighted will be drawn.

[▼] [▼] [F2](CAN)
[▼] [F2](CAN)
[▼] [F2](CAN)

```
GRAPH FUNC:RECT
Y2=2X²-3
r3=5sin 3θ
Xt4=3sin T
Yt4=3cos T
Y5<X²-2X-6
SET CAN      DRW
             F6
```


Draw the graph.

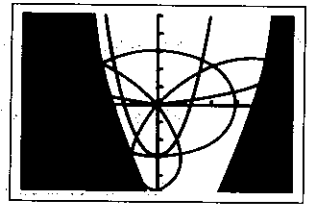
[F6](DRW)



• To overlay graphs for all the functions in memory

Example 2 **To overlay graphs for all the functions using the same range parameters as in Example 1:**

[F5](SEL)
[F6](DRW)



7-11 Other Graph Functions

The functions described in this section can be used with rectangular coordinate, polar coordinate, parametric, inequality, and statistical graphs.

Important

You should enter the COMP, SD, REG, MAT or GRAPH Mode to perform the operations described in this section. Here, we will explain all operations using the COMP Mode only.

■Setting the Type of Graphing Method

There are two types of graphing methods that you can choose between: *connection* (CON) and *plotting* (PLOT).
With the connection method, points that are plotted are connected by lines. With the plotting method, only the points are plotted, without connection.

• To specify the drawing method

[SHIFT] [SETUP] [▼]

```
▶DRAW TYPE :CON
```

Press [F1](CON) to select connection or [F2](PLT) to select plotting.

[F1](CON)

[EXIT]

```
   RUN  / COMP
G-type  : REC/CON
```

Graphing type
- CON = connection
- PLT = plotting

■Trace Function

The Trace Function lets you move a pointer along the line in a graph and display coordinate values at any point. The following illustrations show how values are displayed for each type of graph.

•Rectangular Coordinate Graph

```
X=0. 6684239 Y=0. 6197498
```

•Polar Coordinate Graph

```
r=0. 7880549 θ=2. 1991148
```

•Parametric Graph

```
T=5. 8826322
X=-0. 389927 Y=0. 9208454
```

•Inequality Graph

```
X=1. 4705327 Y≤-0. 675066
```

• To determine the values of points of intersection

Example **To determine the values of the points of intersection for the following equations:**

$y = x^2 - 3$

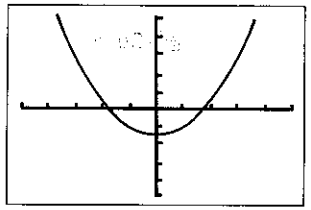
$y = -x + 2$

Use the following range parameters:

```
Range
Xmin:-5.
 max:5.
 scl:1.
Ymin:-10.
 max:10.
 scl:2.
INIT TRG
```

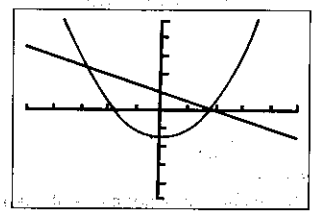

Draw the graph of the first equation.

[MENU](COMP)[EXE](or [1])
[SHIFT][SETUP][F1](REC)[EXIT]
[SHIFT][5](Cls)[EXE]
[Graph][X,θ,T][x²][−][3][EXE]



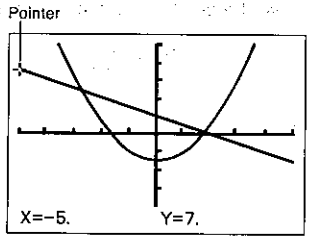
Overdraw the graph of the second equation.

[Graph][(−)][X,θ,T][+][2][EXE]



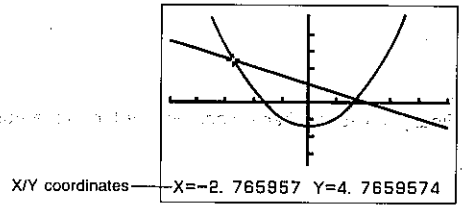
Press [F1](Trace) to activate the Trace Function.

[F1](Trace)

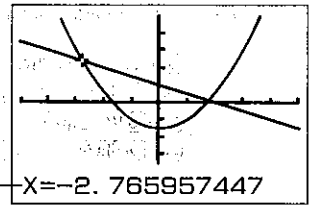


Move the pointer using ▶ and ◀. Holding down either key moves the pointer at high speed.
Move the pointer to the first intersection.
When the pointer is at the location you want, press [F6](Coord) to view coordinates individually. Each press of [F6](Coord) changes the coordinate display in the following sequence:

▶ ~ ▶

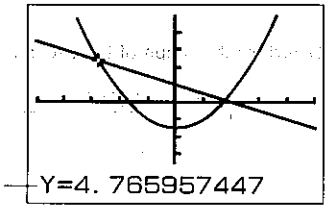


[F6](Coord)



X coordinate only

[F6](Coord)



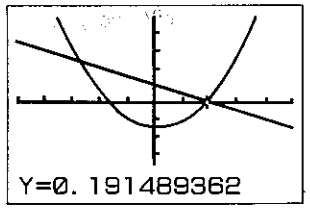
Y coordinate only

Important

The pointer does not move at fixed intervals. It follows the dots on the display. Because of this, the values provided for coordinates are approximate.

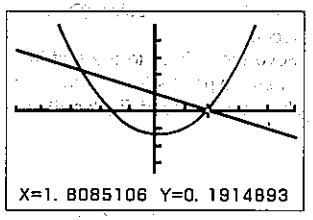
Move the pointer to the next intersection.

◀ ~ ▶



You can then use [F6](Coord) to view the x and y coordinate values.

[F6](Coord)



Finally, press [F1](Trace) again to exit the Trace Function.

• To move the trace between two graphs

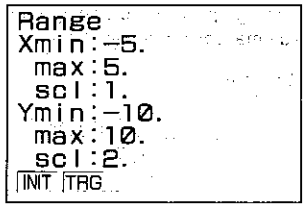
This operation can be used to trace multiple graphs on the same display. In the COMP, SD, REG, or MAT Mode this operation can be used with up to six graphs that are layered using multi-statements or programming. In the GRAPH Mode, all graphs that are drawn on the display can be traced.

Example **To trace points on the following equations (using a multistatement):**

$y=(x+2)(x-3)$

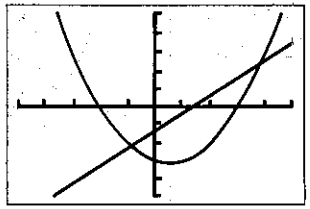
$y=2x-3$

Use the following range parameters:



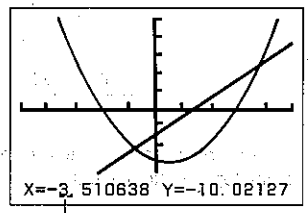
Execute the multistatement that draws the two graphs.

[SHIFT] [SETUP] [F1](REC) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[Graph] [(] [X,θ,T] [+] [2] [)] [(] [X,θ,T] [−] [3] [)]
[SHIFT] [PRGM] [F6](:)
[Graph] [2] [X,θ,T] [−] [3] [EXE]



Press [F1](Trace) to activate the Trace Function. The pointer appears on the graph drawn by the last function in the multistatement. If the unit is in the GRAPH Mode, the pointer appears on the first graph that was drawn.

[F1](Trace)

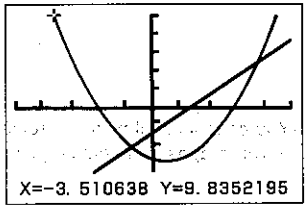


Pointer

Move the pointer along the line where it is located using ▶ and ◀. Holding down either key moves the pointer at high speed.

Use ▲ and ▼ to move the pointer between the two graphs.

▲(or ▼)



Note

- If you have more than two graphs shown on the display, the ▲ and ▼ cursors can be used to move the pointer from graph to graph.
  When you are finished, press [F1](Trace) again to exit the Trace Function.

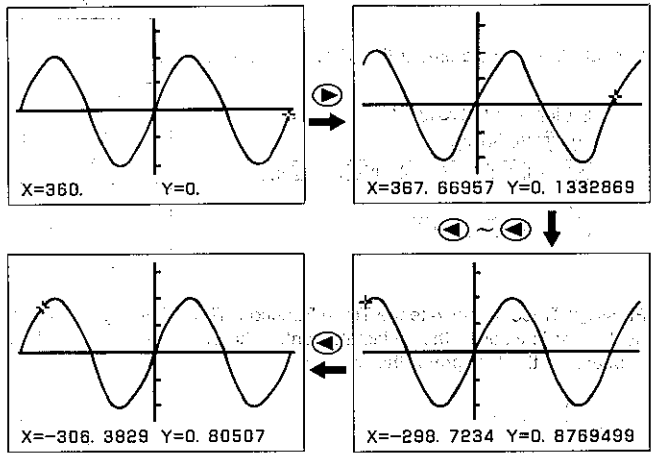
■Scrolling Graphs

If the graph you are tracing runs off the display to the left or right, the display scrolls automatically to follow the Trace Function pointer as you trace the graph.

Example

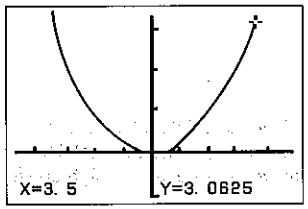
[SHIFT] [DRG] [F1](Deg) [EXE]
[Graph] [sin] [EXE]

[F1](Trace)
[▶] ~ [▶]



- If the graph you are tracing runs off the display to the top or bottom, the display does not scroll.

[▶] ~ [▶]



- You cannot scroll polar coordinate or parametric graphs. You also cannot scroll overdrawn graphs that contain polar coordinate or parametric graphs.

■Notes on Using the Trace Function

- You can use the Trace Function immediately after you draw a graph only. If you draw a graph and then perform a calculation or any other operation (besides [M]-Disp, Range, or G-T), the Trace Function will be unavailable.
- The coordinate values at the bottom of the display are shown with a 10-digit mantissa, or with a 5-digit mantissa and 2-digit exponent. When both the x-coordinate value and the y-coordinate value are shown at the bottom of the display, they appear with an 8-digit mantissa, or with a 4-digit mantissa and a 2-digit exponent. Negative values are one digit shorter because one digit is used for the negative sign.
- You cannot use the Trace Function during program execution.
- Once program execution is suspended by a "◢" symbol, you can use the Trace Function on an graph produced at that point.
- If you are drawing multiple graphs using multistatements, you can use the Trace Function to trace a graph that is displayed by a display result command (page 30). When you press [EXE] to resume drawing of the next graph, the Trace Function is automatically cancelled and the pointer disappears from the display.

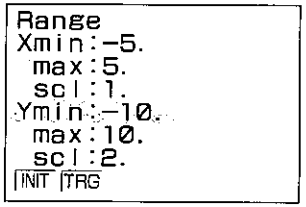
■Plot Function

The Plot Function makes it possible to plot points anywhere on a graph.

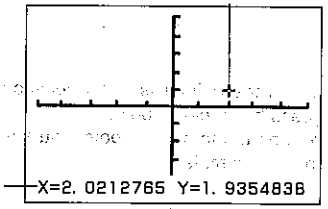
Note that there are two different plot operations: one for graphs in the COMP, SD, REG, and MAT Modes, and another for graphs in the GRAPH Mode.

• To plot points in the COMP, SD, REG and MAT Modes

Example **To plot a point at $x=2$, $y=2$, with the following range parameters:**



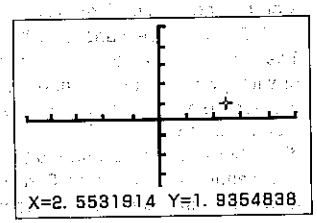
[SHIFT] [F5](Cls) [EXE]
[SHIFT] [F3](Plot) [2] [SHIFT] [,] [2] [EXE]



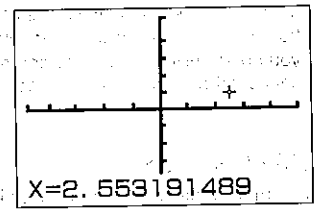
A313025-28

Move the pointer using ▶, ◀, ▲ and ▼. Holding down these keys moves the pointer at high speed.

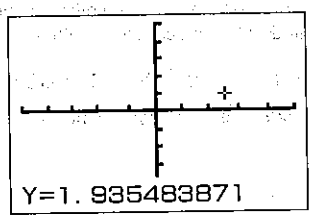
▶▶▶▶▶



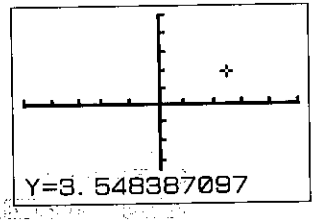
[F6](Coord)



[F6](Coord)

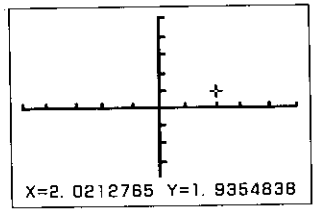


▲▲▲▲▲



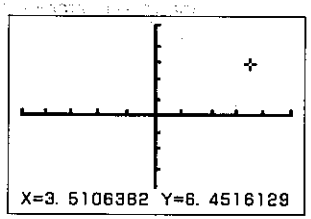
When the pointer is at the location you want, press [EXE] to plot a point.
returns to the original point you specified (2, 2 in this example).

[EXE]



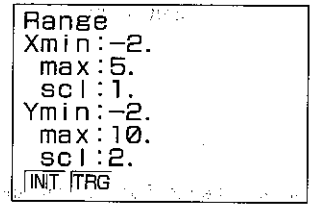
You can change the original point at any time by pressing [F3](Plot) and inputting new coordinates.

[F3](Plot)[3][•][5][SHIFT][,]
[6][•][5][EXE]

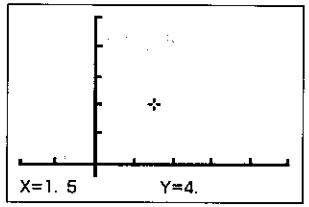


Note

- In the above example, we specified a starting point of 2, 2. You can also enter the graph display to plot points by simply pressing [F3](Plot) followed directly by [EXE].



[SHIFT][F3](Plot)[EXE]



- If you specify a point that is outside the range set up by the range parameters, the pointer does not appear on the display.
- The x-coordinate value of the current pointer location is stored in the **X** value memory. The y-coordinate value is stored in the **Y** value memory.

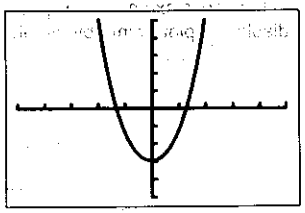
• To plot points in the GRAPH Mode

Example **To plot a point on the graph represented by $y = 2x^2 - 3$, with the following range parameters:**

```
Range
Xmin:-5.
 max:5.
 scl:1.
Ymin:-5.
 max:5.
 scl:1.
INIT TRG
```

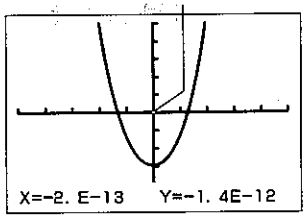
First draw the graph for $y = 2x^2 - 3$ using the procedures described on page 168.

F6(DRW)



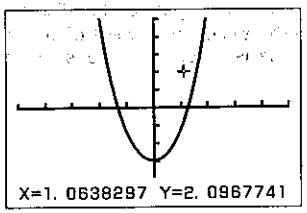
Activate the Plot Function, and the pointer appears flashing in the center of the display.

F3(Plot)

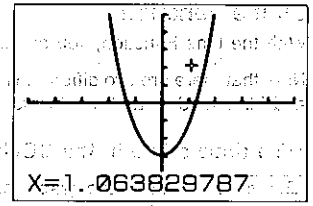


Use the cursor keys to move the pointer around the display.

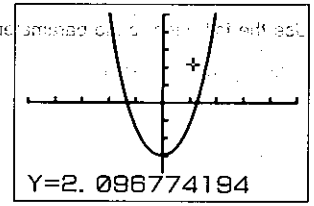
◀ ~ ▶
▲ ~ ▼



F6(Coord)

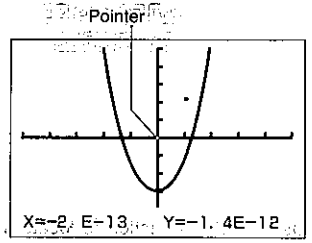


F6(Coord)



When the pointer is at the location you want, press EXE to plot a point.

You can return the pointer to the center of the display at any time by pressing F3(Plot).



Notes

- You can switch the Plot Function off by pressing F5(Cls). When you do, the graph is cleared from the display and then redrawn, without the points that you plotted.
- Whenever you are using the Plot Function, the location of the pointer is maintained in value memory. The x-coordinate is stored in value memory X, while the y-coordinate is stored in value memory Y.

■Line Function

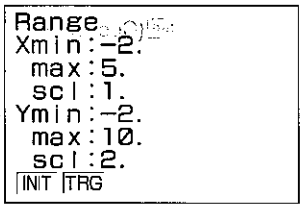
With the Line Function, you can link two points with a straight line.

Note that there are two different line operations: one for graphs in the COMP, SD, REG, and MAT Modes, and another for graphs in the GRAPH Mode.

• To draw a line in the COMP, SD, REG and MAT Modes

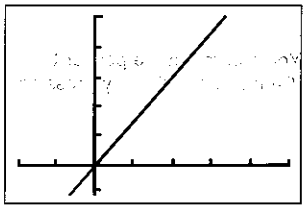
Example **To draw the graph for $y=3x$, and then draw a line from the point on the graph where $x=2$ and $y=6$:**

Use the following range parameters:



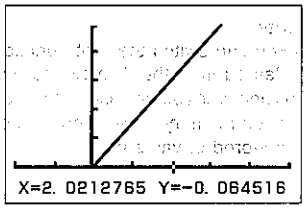
Draw the graph.

SHIFT F5 (Cls) EXE
Graph 3 X,θ,T EXE



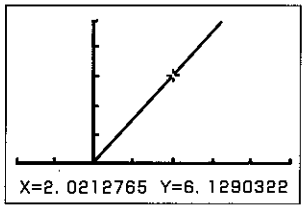
Use the Plot Function to locate the pointer at $x=2$, $y=0$.

F3 (Plot) 2 SHIFT , 0 EXE



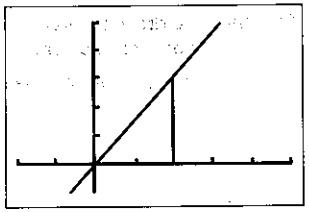
Move the pointer up to the graph line.

F3 (Plot) 2 SHIFT , 0 EXE
▲ ~ ▲



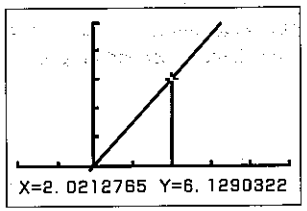
Draw the line.

F4 (Line) EXE



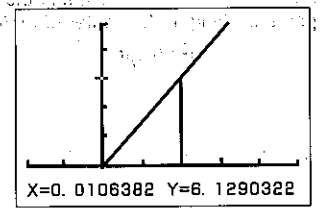
Now draw another line to the y-axis. Since the x- and y-coordinates of the point you last plotted are stored in **X** and **Y** value memories, you can easily move the pointer back to the point on the graph. Note the following operation.

F3 (Plot) ALPHA X SHIFT , ALPHA Y
EXE



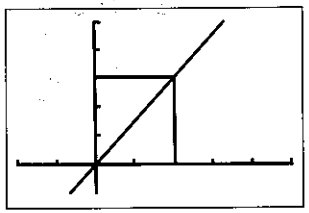
Move the pointer to the y-axis.

◀ ~ ◀



Draw the line.

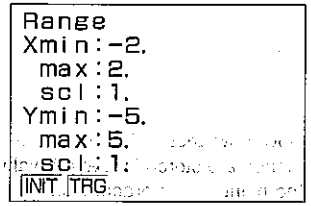
F4 (Line) EXE



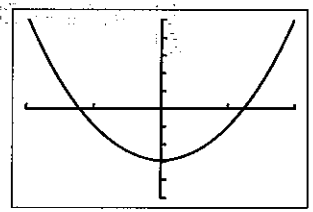
• To draw lines in the GRAPH Mode

Example **To draw the graph for $y=2x^2-3$ and then draw a line from the minimum point on the graph to the point where $x=2$ and $y=5$:**

Use the following range parameters:

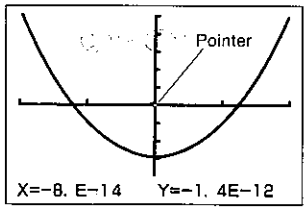


First draw the graph for $y=2x^2-3$ using the procedures described on page 168.



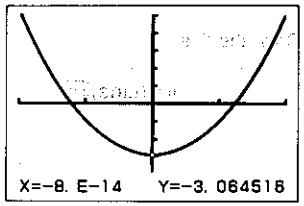
Activate the Plot Function, and the pointer appears flashing in the center of the display.

F3(Plot)



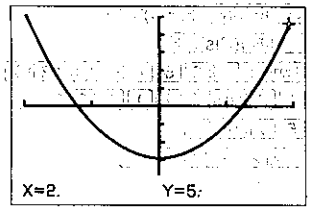
Use the cursor keys to move the pointer to the minimum point on the graph, and press EXE.

▼ ~ ▼ EXE



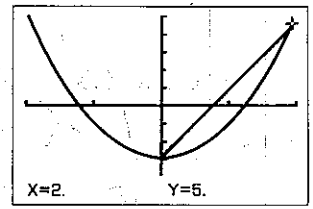
Use the cursor keys to move the pointer to the point where $x=2$ and $y=5$.

▶ ~ ▶
▲ ~ ▲



Press F4(Line) to connect the two points with a line.

F4(Line)



Note

•You can switch the Line Function off by pressing F5(Cls). When you do, the graph is cleared from the display and then redrawn, without the lines you drew.

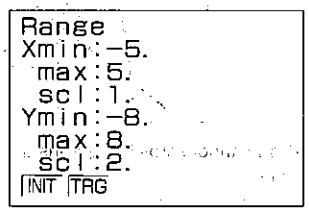
■Graph Scroll Function

Immediately after you have drawn a graph, you can scroll it on the display. Use the cursor-keys to scroll the graph left, right, up and down. The display is scrolled in increments of 12 dots, with the display being redrawn after each scroll operation.

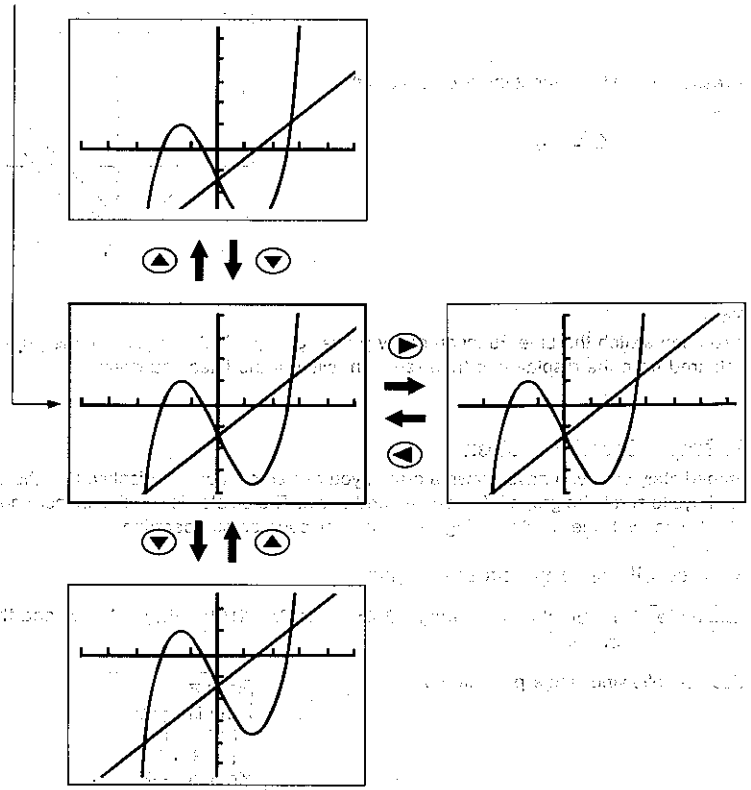
• To scroll the graph on the display

Example **To draw the graph for $y=0.25(x+2)(2x+1)(2x-5)$, $y=2x-3$, and then scroll it:**

Use the following range parameters:



[SHIFT] [SETUP] [F1] (REC) [EXIT]
[SHIFT] [F5] (Cls) [EXE]
[Graph] [0] [•] [2] [5] [(] [X,θ,T] [+] [2] [)]
[(] [2] [X,θ,T] [+] [1] [)] [(] [2] [X,θ,T] [−]
[5] [)] [SHIFT] [↵]
[Graph] [2] [X,θ,T] [−] [3] [EXE]



•You cannot scroll bar graphs and line graphs produced using single-variable statistical data.

■Zoom Functions

The Enlarge and Reduce Functions let you zoom in and out on graphs.

• To display the Zoom Menu

[SHIFT] [F2] (Zoom)

BOX	FCT	×f	×1/f	ORG
[F1]	[F2]	[F3]	[F4]	[F5]

•The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

- [F1] (BOX) ..... Box Function
- [F2] (FCT) ..... Displays the factor input screen
- [F3] (×f) ..... Zooms in or out on the graph in accordance with the zoom factors
- [F4] (×1/f) ..... Zooms in or out on the graph in accordance with the inverse of the zoom factors
- [F5] (ORG) ..... Restores a graph zoomed using the Box Function or factor zooming to its original size, based on the graph's range parameters

■Box Function

The Box Function lets you cut out a specific section of a graph for zooming.

• To zoom in on a part of a graph

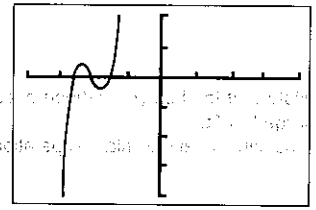
Example **To specify a box on the graph for $y=(x+5)(x+4)(x+3)$, with the following range parameters:**

Specify the range parameters.

```
Range
Xmin:−8.
 max:8.
 scl:2.
Ymin:−4.
 max:2.
 scl:1.
INIT TRG
```

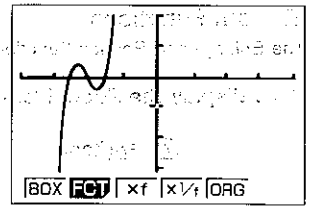
Draw the graph.

[SHIFT] [SETUP] [F1] (REC) [EXIT]
[SHIFT] [F5] (Cls) [EXE]
[Graph] [(] [X,θ,T] [+] [5] [)] [(] [X,θ,T] [+]
[4] [)] [(] [X,θ,T] [+] [3] [)] [EXE]



Press [F2](Zoom) to activate the Zoom Function, and a pointer appears flashing in the center of the display.

[F2](Zoom)

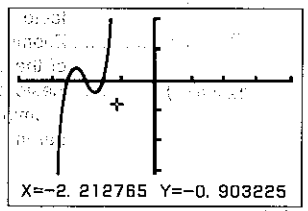


[F1]

Press [F1](BOX) and move the pointer using the cursor keys.
Once the pointer is located where you want one corner of the box to be, press [EXE].

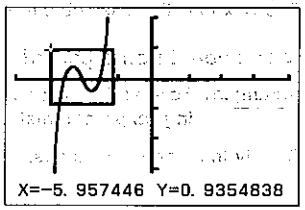
- To display the coordinates of the current pointer location, press [EXIT] twice or press [SHIFT][QUIT].

[F1](BOX)[EXIT][EXIT]
[▲][◀] ~ [◀][EXE]



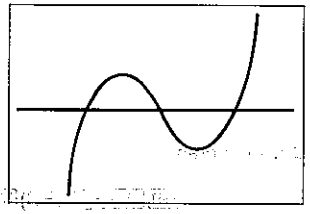
Move the pointer to the location of the corner diagonally opposite the one you have just set. Note that a box automatically appears on the display.

[▲] ~ [▲][◀] ~ [◀]



When the pointer is located where you want the other corner of the box to be, press [EXE].

[EXE]

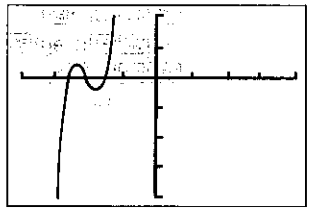


Note that the box you defined becomes the outline of the display, and the graph is enlarged to fit.
You can repeat the enlarge operation and make enlargements of part of an enlarged graph.

• To return a graph to its original size

Example **To return to the graph enlarged above to its original size:**

[F2](Zoom)[F5](ORG)



- If you locate the second corner of the box horizontally or vertically with the first corner, no box is formed, and so the graph is not enlarged.
- For graphs drawn in the COMP, SD, REG, or MAT Mode, the Box Function can be used to zoom only the most recently drawn six graphs. In the case of the GRAPH Mode, the Box Function can be used to zoom any graphs drawn.

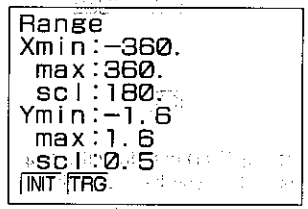
■Using the Factor Function to Enlarge and Reduce the Entire Graph

You can enlarge or reduce the entire graph. You can set different factors for the x and y-axes, which means that you can double the length while leaving the height unchanged, or vice versa.
With this function, you can use a pointer that appears on the display to select a point on the graph to be the center of the zoomed area. If you do not specify a point, the center of the normal size graph is used as the center of the enlarged or reduced graph.

• To enlarge a graph

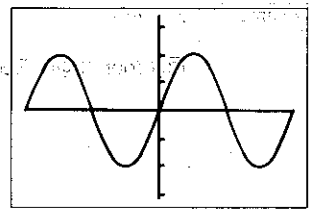
Example **To enlarge the graph for $y = \sin x$ by 1.5 times on the x-axis and 2 times on the y-axis, using the following range parameters:**

Specify the range parameters.



Draw the graph.

[SHIFT] [SETUP] [F1](REC) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[SHIFT] [ORG] [F1](Deg) [EXE]
[Graph] [sin] [X,θ,T] [EXE]



Press [F2](Zoom) to display the Zoom Menu.

[F2](Zoom)

BOX **FCT** ×f ×1/f ORG

[F2]

Press [F2](FCT) to display the Factor Input Screen.

[F2](FCT)

```
Factor
Xfct:2.
Yfct:2.
INIT
```

Input the zoom factors for the *x*-axis and *y*-axis.

[1] [•] [5] [EXE]

```
Factor
Xfct:1.5
Yfct:2.
```

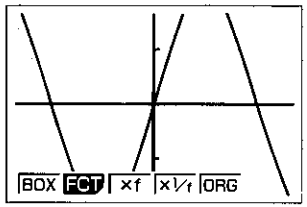
[2] [•] [0] [EXE]

```
Factor
Xfct:1.5
Yfct:2.0
```

[EXIT]

Press [F3](×f) to redraw the graph according to the factors you have specified.

[F3](×f)



At this time, the range parameters are changed as follows:

[Range]

```
Range
Xmin:-240.
 max:240.
 scl:180.
Ymin:-0.8
 max:0.8
 scl:0.5
INIT TRG
```

You can repeat the enlarge operation and enlarge the enlarged graph again.

• To reduce a graph

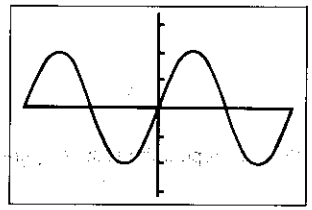
Example **To reduce the graph for $y = \sin x$ by 1.5 times on the *x*-axis and 2.0 times on the *y*-axis, using the following range parameters:**

Specify the range parameters.

```
Range
Xmin:-360.
 max:360.
 scl:180.
Ymin:-1.6
 max:1.6
 scl:0.5
INIT TRG
```

Draw the graph.

[SHIFT] [SETUP] [F1](REC) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[SHIFT] [ORG] [F1](Deg) [EXE]
[Graph] [sin] [X,θ,T] [EXE]



Press [F2](Zoom) to display the Zoom Menu.

[F2](Zoom)

BOX **FCT** ×f ×1/f ORG

[F2]

Press [F2](FCT) to display the Factor Input Screen.

[F2](FCT)

```
Factor
Xfct:2.
Yfct:2.
```

Input the zoom factors for the x-axis and y-axis.

[1] [•] [5] [EXE]

```
Factor
Xfct:1.5
Yfct:2.
```

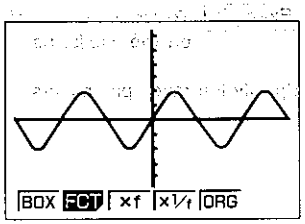
[2] [•] [0] [EXE]

```
Factor
Xfct:1.5
Yfct:2.0
```

[EXIT]

Press [F4](×1/f) to redraw the graph according to the factors you have specified.

[F4](×1/f)



At this time, the range parameters are changed as follows:

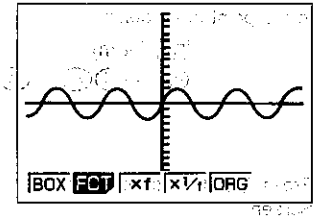
```
Range
Xmin:−540.
 max:540.
 scl:180.
Ymin:−3.2
 max:3.2
 scl:0.5
INIT TRG
```

You can repeat the reduce operation and reduce the reduced graph again.

• To redraw a graph using the inverse of the factors

Continuing from the graph reduction example above, press [F2](Zoom) and then [F4](×1/f).

([Range] [Range])
[F4](×1/f)



At this time, the range parameters are changed as follows:

[Range]

```
Range
Xmin:−810.
 max:810.
 scl:180.
Ymin:−6.4
 max:6.4
 scl:0.5
INIT TRG
```

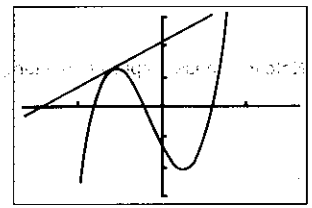
• To specify the center point of an enlarged display

Example **To enlarge the graphs: $y=(x+4)(x+1)(x-3)$, and $y=3x+22$ by 5 times on the x-axis and y-axis, with the apparent point of tangency at the center of the display. Use the following range parameters:**

```
Range
Xmin:−8.
 max:8.
 scl:5.
Ymin:−30.
 max:30.
 scl:10.
INIT TRG
```

Draw the graph.

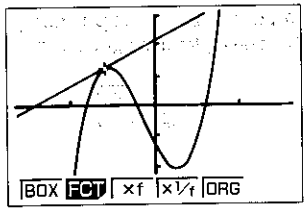
[SHIFT] [SET UP] [F1](REC) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[Graph] [(] [X,θ,T] [+] [4] [)] [(] [X,θ,T] [+]
[1] [)] [(] [X,θ,T] [−] [3] [)] [SHIFT] [↵]
[Graph] [3] [X,θ,T] [+] [2] [2] [EXE]



Press [F2](Zoom) to display the Zoom Menu and the pointer appears flashing in the center of the display. Use the cursor keys to move the pointer to the point of tangency.

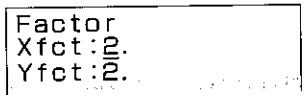
[F2](Zoom)

◀ ~ ◀ ▲ ~ ▲



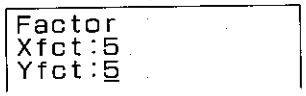
Press [F2](FCT) to display the Factor Input Screen.

[F2](FCT)

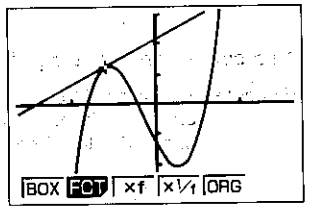


Input the zoom factors for the *x*-axis and *y*-axis.

[5] [EXE] [5] [EXE]



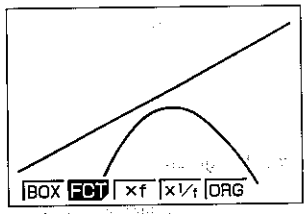
[EXIT]



[F3]

Press [F3](×f) to redraw the graph according to the factors you have specified.

[F3](×f)

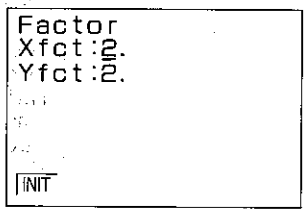


Note that these graphs are not tangent as they appear on the normal (unenlarged) display.

• To initialize the zoom factors

[F2](Zoom) [F2](FCT) [F1](INIT)

Anytime you perform the above operation, the unit initializes the zoom factors to the following settings.



• To specify the zoom factors within a program

Use the following format to specify the zoom factors in a program.

Factor (Xfct), (Yfct)

Note

•For graphs drawn in the COMP, SD, REG, or MAT Mode, the Factor Zoom can be used to zoom only the most recently drawn six graphs. In the case of the GRAPH Mode, Factor Zoom can be used to zoom any graphs drawn.

■Using the Overwrite Function

You can use the following format, specifying your own values for the value memory where indicated, to draw more than one graph on the display at the same time.

[Graph] function [SHIFT] [,] [ALPHA] [C] value memory [SHIFT] [PRGM] [F2](REL) [F1](=) any value [SHIFT] [,] any value [SHIFT] [,] ... any value [ALPHA] [)] [EXE]

Notes

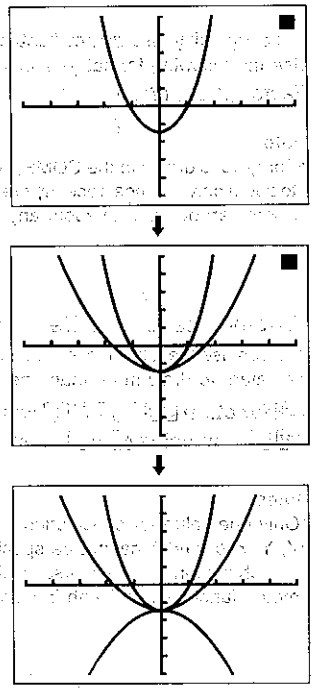
•Only one value for substitution of values can be used in the above format.
•X, Y, *r*, *θ*, and T cannot be specified as the value memory.
•The above format can be used with rectangular coordinate, polar coordinate, and parametric functions, and with inequalities only.

• To overwrite graphs

Example To draw graphs by substituting the values 3, 1, and −1 for A in the function $y = Ax^2 - 3$. Use the following range parameters:

```
Range
Xmin:−5.
 max:5.
 scl:1.
Ymin:−10.
 max:10.
 scl:2.
INIT TRG
```

SHIFT SETUP F1(REC) EXIT
SHIFT F5(Cls) EXE
Graph ALPHA A X,θ,T x² − 3
SHIFT , ALPHA (ALPHA A
SHIFT PRGM F2(REL) F1(=)
3 SHIFT , 1 SHIFT , (−) 1
ALPHA) EXE



7-12 Some Graphing Examples

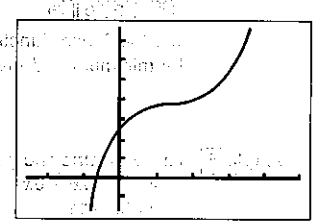
The following examples are presented to show you some ways that the graphing functions can be used effectively.
Note that all of these examples are performed in the COMP Mode.

Example 1 To graph the function $y = x^3 - 9x^2 + 27x + 50$:

Use the following range parameters.

```
Range
Xmin:−5.
 max:10.
 scl:2.
Ymin:−30.
 max:150.
 scl:20.
INIT TRG
```

SHIFT SETUP F1(REC) EXIT
SHIFT F5(Cls) EXE
Graph X,θ,T ^ 3 − 9 X,θ,T x²
+ 2 7 X,θ,T + 5 0 EXE

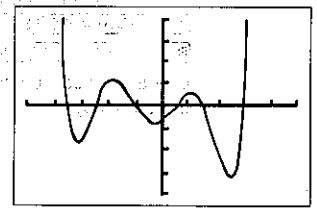


Example 2 To graph the function $y = x^6 + 4x^5 - 54x^4 - 160x^3 + 641x^2 + 828x - 1260$:

Use the following range parameters.

```
Range
Xmin:−10.
 max:10.
 scl:2.
Ymin:−8000.
 max:8000.
 scl:2000.
INIT TRG
```

SHIFT F5(Cls) EXE
Graph X,θ,T ^ 6 + 4 X,θ,T ^ 5
− 5 4 X,θ,T ^ 4 − 1 6 0
X,θ,T ^ 3 + 6 4 1 X,θ,T x²
+ 8 2 8 X,θ,T − 1 2 6 0 EXE



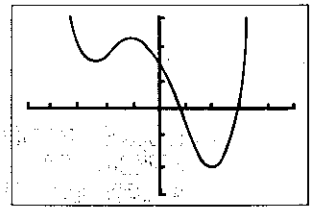
Example 3 To graph the function $y = x^4 + 4x^3 - 36x^2 - 160x + 300$ and determine its minimum and maximum:

Use the following range parameters.

```
Range
Xmin:−10.
 max:10.
 scl:2.
Ymin:−600.
 max:600.
 scl:200.
INIT TRG
```

[SHIFT] [F5] (Cls) [EXE]
[Graph] [X,θ,T] [^] [4] [+] [4] [X,θ,T] [^] [3]
[−] [3] [6] [X,θ,T] [x²] [−] [1] [6] [0] [X,θ,T]
[+] [3] [0] [0] [EXE]

Use the Trace Function to find the minimum and maximum.



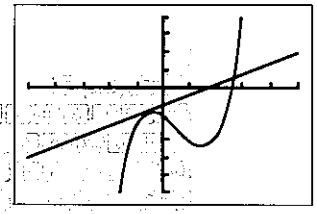
Example 4 To determine the points of tangency for the following functions:
$y = x^3 - 3x^2 - 6x - 16$
$y = 3x - 11$

Use the following range parameters.

```
Range
Xmin:−10.
 max:10.
 scl:2.
Ymin:−60.
 max:40.
 scl:10.
INIT TRG
```

[SHIFT] [F5] (Cls) [EXE]
[Graph] [X,θ,T] [^] [3] [−] [3] [X,θ,T] [x²]
[−] [6] [X,θ,T] [−] [1] [6] [SHIFT] [↵]
[Graph] [3] [X,θ,T] [−] [1] [1] [EXE]

Use the Trace Function to find the tangency.

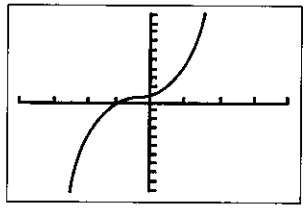


Example 5 To store $x^3 + 1$, $x^2 + x$ into Function Memory (page 39), and then graph: $y = x^3 + x^2 + x + 1$

Use the following range parameters:

```
Range
Xmin:−4.
 max:4.
 scl:1.
Ymin:−10.
 max:10.
 scl:1.
INIT TRG
```

[SHIFT] [SETUP] [F1] (REC) [EXIT]
[AC]
[X,θ,T] [^] [3] [+] [1] [SHIFT] [F:MEM] [F1] (STO) [1]
[AC] (stores $(x^3 + 1)$)
[X,θ,T] [x²] [+] [X,θ,T] [F1] (STO) [2]
[AC] (stores $(x^2 + x)$)
[SHIFT] [F5] (Cls) [EXE]
[Graph] [F3] (fn) [1] [+] [F3] (fn) [2] [EXE]



Chapter 8

Programming

8-1 Introduction to Programming
8-2 Deleting Programs
8-3 About Error Messages
8-4 Counting the Number of Bytes
8-5 Program Commands
8-6 Using Jump Commands
8-7 Using Subroutines
8-8 Using Array Memory
8-9 Displaying Text Messages
8-10 Using Matrices in Programs
8-11 Using the Graph Function in Programs

Chapter 8 Programming

This chapter tells you how to use the versatile program memory of the unit. Once you program a calculation, you can call it up and execute it using any values you want at the touch of a key.

8-1 Introduction to Programming

The following explains the basics about programming the unit. We also provide a number of actual easy-to-understand examples for your reference. For full details on each of the programming operations, see the other sections in this chapter.

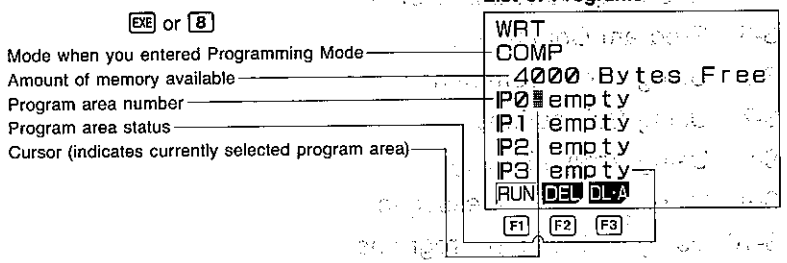
■To Enter the Programming Mode

Highlight the **PRGM** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] or [8] to display the Programming (PRGM) Mode.



The above display shows that there are 4,000 bytes of memory available to store programs. Though you can see only four program area names, there are actually a total of 38, named P0 through P9, PA through PZ, Pr, and Pθ.

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

[F1](RUN) ..... Program execution
[F2](DEL) ..... Specific program delete
[F3](DL·A) ..... All program delete

■Specifying the Calculation Mode

Before starting a programming operation, you should first specify the calculation mode (CAL MODE) that matches the calculation you plan to program. The mode you select determines the type of function key menu that appears on the bottom of the display.

• To specify the calculation mode

Perform the following operation while the list of programs is displayed.

[SHIFT] [SETUP]

```
▶CAL MODE    :COMP
CMP BAS S D REG MAT
F1  F2  F3  F4  F5
```

The following are the calculation modes that can be selected from the function menu at the bottom of the display. Press the function key below the calculation mode you want to select.

[F1](CMP) ..... Computation Mode
[F2](BAS) ..... BASE Mode
[F3](SD) ..... Standard Deviation Mode
[F4](REG) ..... Regression Mode
[F5](MAT) ..... Matrix Mode

*Pressing [EXIT] returns to the programming display menu.

■Selecting a Program Area

You can select a program area by moving the cursor to it using the [▲] and [▼] keys, or by directly inputting the number of letter that names the program area.

• To select a program area using the cursor keys

[▼][▼]

```
 4000 Bytes Free
P0 empty
P1 empty
P2 empty
```

• To select a program area using direct input

[2]

```
 4000 Bytes Free
P2 empty
P3 empty
P4 empty
```

■Checking How Much Memory Is Used by a Program

You can check how much memory is used by a program either while the list of programs is displayed, or while you are inputting a program.

• Checking memory from the list of programs

1. Use the ▲ and ▼ keys to move the cursor to the program area whose memory status you want to check.
2. Hold down the [M+] key. The bottom line of the display shows the program area number and the number of bytes it contains.

• Checking memory while programming

Hold down the [M+] key. The bottom line of the display shows the current program area number and the number of bytes it contains.

```
Bytes P4=108
```

Program area number — Number of bytes

■To Input a Program

Example **To program the following formulas, which calculate the surface area (S) and volume (V) of a regular octahedron when the length of one side (A) is known. Store program in area P5.**

$S = 2\sqrt{3}A^2 \quad V = \sqrt{2}/3A^3$

[MENU] (PRGM) [EXE] (or [8])
▼▼▼▼▼

```
WRT
COMP
 4000 Bytes Free
P2 empty
P3 empty
P4 empty
P5 empty
RUN DEL DL-A
```

[EXE](Starts programming)

```
_
```

[SHIFT][PRGM][F4](?)[→][ALPHA][A][F6](:)
[2][×][SHIFT][√][3][×][ALPHA][A][x²]
[F5](◢)

```
?→A:2×√3×A²◢
_
```

```
JMP REL Prg ? ◢ :
F1  F2  F3  F4 F5 F6
```


[SHIFT][√][2][÷][3][×][ALPHA][A][^][3]

[SHIFT][QUIT] (or [EXIT][EXIT])

```
?→A:2×√3×A²◢
√2÷3×A^3_
```

*"?" is a prompt command for value input.
"◢" is a display result command.

■To Execute a Program Stored in Memory

Example **To execute the program stored by the operation described above, for A = 7, 10 and 15**

Length of one side	Surface area	Volume
7cm	(169.7409791) cm²	(161.6917506) cm³
10	(346.4101615)	(471.4045208)
15	(779.4228634)	(1590.990258)

▼▼▼▼▼

```
WRT
COMP
 3980 Bytes Free
P2 empty
P3 empty
P4 empty
P5?→A:2×√3×A²◢
RUN DEL DL-A
```

[F1](RUN)

```
?
```

[7][EXE](Value of A)

```
?
7
        169.7409791
          - Disp -
```

(S when A = 7)
"– Disp –" pauses calculation for display of result

[EXE]

```
?
7
        169.7409791
        161.6917506
```

(V when A = 7)

[EXE]

```
?
7
        169.7409791
        161.6917506
?
```

[1][0][EXE] (Value of A)

```
?
10
          346.4101615
            - Disp -
```
(S when A = 10)

[EXE]

```
?
10
          346.4101615
          471.4045208
```
(V when A = 10)

(The rest is omitted)

*Program calculations are executed automatically whenever you press [EXE] after inputting data or after a result is displayed.
*If calculation is suspended to display a result, press [EXE] to resume the calculation.
*When you execute program, calculations are performed in the mode (COMP, BASE, SD, REG, MAT) that was selected when you input the program.

8-2 Deleting Programs

You can delete either individual programs or all of the programs stored in memory.

Important

The results of the procedures described below cannot be undone. Make sure that you do not need data any more before you delete it.

• To delete a specific program

Display the list of programs and move the pointer next to the program you want to delete.
Press [F2](DEL).

[F2](DEL)

```
YES DELETE PROGRAM NO
F1                   F6
```

Press [F1](YES) to delete the program, or [F6](NO) to abort the operation without deleting anything.

• To delete all programs

Display the list of programs.
Press [F3](DL·A).

[F3](DL·A)

```
YES DEL ALL PROGRAMS NO
F1                   F6
```

Press [F1](YES) to delete all programs, or [F6] (NO) to abort the operation without deleting anything.

8-3 About Error Messages

Sometimes a program you enter causes an error message to appear when you execute it. This means that there is an error that needs to be corrected. The following shows a typical error message display

```
Syn ERROR      Error type
Bytes P0-8     Bytes where error occurred
               Program area where error occurred
```

All of the possible error messages are listed in the Error Message Table on page 269. When you get an error message, look it up in the Error Message Table and take actions to correct it.

8-4 Counting the Number of Bytes

The memory of this unit can hold up to 4,000 bytes of data. Generally, one function in a program takes up one byte. Some functions, however, require two bytes each.

•1-byte functions
sin, cos, tan, log, (,), A, B, C, 1, 2, etc.

•2-byte functions
Lbl 1, Goto 2, Prog 3, etc.

You can count the bytes in a program by pressing the ◀ and ▶ keys. Each press of these keys causes the cursor to jump one byte. Display of the following is counted as two bytes:

- d/dx (
- Mat, Det, Trn (Mat Mode)
- * Row, * Row +, Row +, Swap (Using matrices in programs)
- Y, r, Xt, Yt, Sim X, Sim Y, Sim Z, Sim Coef, Ply X_1, Ply X_2, Ply Coef (VAR Mode)

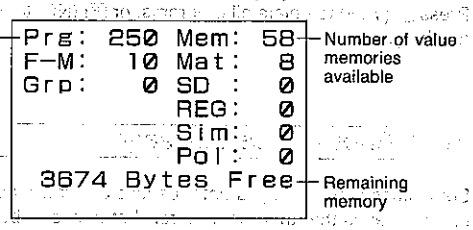
When the number of bytes remaining drops to five or below, the cursor automatically changes from an underline to "■". If you need to input more than five bytes, try to increase the amount of memory available for program storage by deleting unnecessary programs, deleting expanded memory, or by deleting unneeded function memory contents.

■To Check the Amount of Memory Remaining

SHIFT CAPS (Hold Down)

You can also display the remaining memory display by performing the following operation while the COMP, BASE, SD, REG or MAT Modes are displayed.

SHIFT 0afm EXE



■To Check Where the Cursor Is Currently Located

MDisp

(Current location of cursor byte #6)

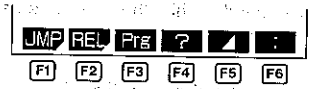
The above screen remains on the display as long as MDisp is depressed.

8-5 Program Commands

The unit provides you with special programming commands that let you perform conditional and unconditional jumps and loops.

■To Display the Program Function Menu

SHIFT PRGM



The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

F1 (JMP) ..... Displays jump command menu
F2 (REL) ..... Displays relational operator menu
F3 (Prg) ..... Inputs "Prog" for program area specification
F4 (?) ..... Prompt command for value input
F5 (◢) ..... Display result command
F6 (:) ..... Multistatement connector

- The input in response to a prompt command "?" can be a value or calculation expression up to 111 bytes long. No non-calculation command or multistatement can be performed while the calculator is waiting for input in response to a prompt command.
- The display result command "◢" causes program execution to stop while the calculation result up to the display result command or a text message is displayed. To resume program execution, press EXE. The final result of the program execution is displayed regardless of whether or not this command is included at the end. Note, however, that this command should be used at the end of the BASE Mode program in order to return the unit to its original mode following the program.
- The multistatement connector ":" is used to connect two or more statements together for sequential execution. Unlike statements connected by the display result command, statements connected by the multistatement connector are executed from beginning to end, non-stop. Note that you can also use the Newline Function (described below) to connect statements, and make them easier to read on the display.

■About the Newline Function

The Newline Function is a multistatement connector that, performs a newline operation instead of inserting a ":" symbol at the connection of two statements.
Note the two following displays.

```
Deg:0→T:?→V:?→S:
Lbl 1:Isz T:Vxsi
n SxT-9.8xT²÷2◢
Goto 1
```

```
Deg
0→T:?→V:?→S
Lbl 1:Isz T:Vxsi
n SxT-9.8xT²÷2◢
Goto 1
```

Both displays show the same programs, except that the upper one uses multistatements commands, while the lower one uses the Newline Function. Note how much easier the lower display is to read.

• To use the Newline Function

To perform a newline operation at the end of a statement, press [EXE].

■To Display the Jump Command Menu

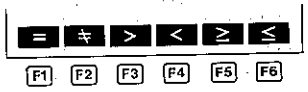
[SHIFT] [PRGM] [F1] (JMP)

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

- [F1] (⇒) ..... Indicates conditional jump destination
- [F2] (Gto) ..... Indicates unconditional jump destination
- [F3] (Lbl) ..... Indicates label
- [F4] (Dsz) ..... Decrements value memory
- [F5] (Isz) ..... Increments value memory

■To display the Relational Operator Menu

[SHIFT] [PRGM] [F2] (REL)



The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

- [F1] (=) ..... Equal
- [F2] (≠) ..... Not equal
- [F3] (>) ..... Greater than
- [F4] (<) ..... Less than
- [F5] (≥) ..... Greater than or equal to
- [F6] (≤) ..... Less than or equal to

■To display the Punctuation Symbol Menu

[ALPHA]

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

- [F1] (') ..... Start of non-executable remarks
- [F2] (") ..... Indicates display text
- [F3] (~) ..... Indicates range of value memories

- The single quotation mark indicates the beginning of non-executable remarks. It is useful to insert a program name at the beginning of the program for display in the program area list (only the first 13 characters are displayed). The unit considers anything from a single quotation mark up to the next multistatement connector (:), display result command (◢), or newline operation to be part of the remarks. Remarks can contain letters or numbers.
- Double quotation marks indicate text to be shown on the display. Display text can contain letters or numbers. The unit considers anything from a double quotation mark up to the next multistatement connector (:), display result command (◢), or newline operation to be part of the display text. Display text can contain letters or numbers.
- The "~" symbol is used to indicate a range of value memories. For example, to assign a value of 10 to value memories A through F, you would specify the following:

10 → A~F ([1] [0] [→] [ALPHA] [A] [ALPHA] [F3] (~) [ALPHA] [F] [EXE])

This symbol cannot be used to assign values to value memories r or θ, but it can be used with array memories (page 214). It is most useful when you want to clear a series of value memories by assigning them with a value of zero in a program.

8-6 Using Jump Commands

Generally, programs are executed from beginning to end, in the order that they are input into memory. This can cause problems when you want to repeat an operation a number of times or when you want to execute a formula in a different location. Jump commands make it possible to accomplish such operations very easily.

■About Unconditional Jumps

An unconditional jump is one that is performed no matter what circumstances exist. To use an unconditional jump with the unit, you first identify the destination of the jump with a label. Then you tell the unit at some point to go to the label and continue execution of the program.

To illustrate, we will reprogram the calculation for the surface area and volume of a regular octahedron that we originally wrote on page 202. With our previous program, we had to start the program three different times to perform our calculations. With an unconditional jump however, once we start program execution, it repeats until we tell it to stop.

• To use an unconditional jump

Example 1

Previous Program

?, →, A, :, 2, ×, √, 3, ×, A, x^2, ◢, √, 2, ÷, 3, ×, A, ^, 3

20 bytes

New Program

Lbl, 1, :, ?, →, A, :, 2, ×, √, 3, ×, A, x^2, ◢, √, 2, ÷, 3, ×, A, ^, 3, ◢, Goto, 1

26 bytes

Note that in the new program, we identify the start of the program with label 1 (Lbl 1). This is where we want to jump to each time. Then at the end of the program we include the jump command to "go to label 1" (Goto 1).
Input the program (using the procedures described on page 202), and you should be able to perform the following calculation.

F1(RUN)	?
7 EXE	169.7409791
EXE	161.6917506
EXE	?
1 0 EXE	346.4101615
EXE	471.4045208

(The rest is omitted)

In the above example we located the destination of the branch at the beginning of the program. Actually, you can locate destinations anywhere. Note the next example.

Example 2 **To program the formula $y = Ax + B$, so that for each execution the values of A and B remain constant, but the value of x varies.**

Program

?, →, A, :, ?, →, B, :, Lbl 1, :, ?, →, X, :, A, ×, X, +, B, ◢, Goto 1 — 23 bytes

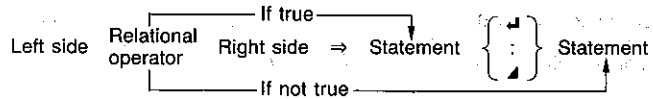
With this program, a prompt appears once for A and B. A prompt for X appears with each execution of the loop back to label 1 (Lbl 1).

Note

*If your program tells the calculator to go to a label that does not exist, an error message (Go ERROR) appears on the display.

■ About Conditional Jumps

With a conditional jump you set up certain criteria and control whether or not the jump is actually performed. Look at the following format.



As shown above, if the condition defined by the relational operator is true, the statement following "⇒" is executed, and then the next statement is executed. If the condition is false, the statement following "⇒" is skipped.
The following are the conditions that you can define using the relational operators.

L = R ..... True when L and R are equal; false when L and R are not equal
L ≠ R ..... True when L and R are not equal; false when L and R are equal
L > R ..... True when L is greater than R; false when L is less than or equal to R
L < R ..... True when L is less than R; false when L is greater than or equal to R
L ≥ R ..... True when L is greater than or equal to R; false when L is less than R
L ≤ R ..... True when L is less than or equal to R; false when L is greater than R

• To use a conditional jump

Example 1 **To write a program that calculates the square root of any input value that is greater than or equal to zero. If a value that is less that zero is input, the program ignores it and prompts further input.**

Program

Lbl, 1, :, ?, →, A, :, A, ≥, 0, ⇒, √, A, ◢, Goto, 1 — 16 bytes

This program starts out by prompting input for A. The next statement tests the input by saying: "if the value of A is greater than or equal to 0, then calculate the square root of A". This is followed by a display result command. After the result is displayed, pressing EXE continues with the Goto 1 unconditional jump to label 1 (Lbl 1) at the beginning of the program. For values that are less than 0, the square root calculation statement is skipped and execution jumps directly to the Goto 1 statement.

Example 2 **To write a program that accumulates input values, but displays the total of the values any time zero is entered.**

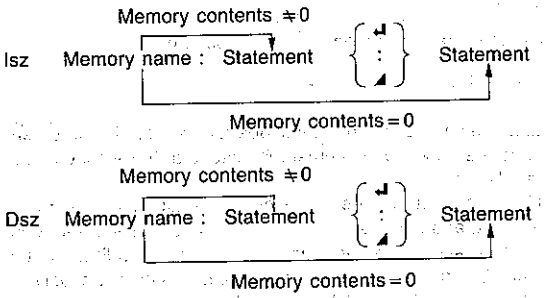
Program

0, →, B, :,
Lbl, 1, :, ?, →, A, :, A, =, 0, ⇒, Goto, 2, :,
A, +, B, →, B, :, Goto, 1, :,
Lbl, 2, :, B — 31 bytes

With this program, 0 is assigned to value memory B to clear it. The next statement prompts for input of a value to value memory A. The next statement is a conditional jump that says: "if the value input for A equals 0, then go to label 2". The statement following label 2 (Lbl 2) ends program execution with a display of the value memory B contents. For other values, the next statement adds value memories A and B, and then stores the result in value memory B again. After this, program execution returns to the statement following label 1 (Lbl 1), where the next input for A is prompted.

■About Count Jumps

There are two count jumps: one that increments a value memory (Isz) and one that decrements a value memory (Dsz). Look at the following format.



As shown above, if the increment or decrement operation does not cause the content of the value memory to become 0, the statement following the value memory name is executed. If the content of the value memory becomes 0, the next statement is skipped.

• To use a count jump

Example 1 **To write a program that accepts input of 10 values, and then calculates the average of the values.**

Program

1, 0, →, A, :, 0, →, C, :,
Lbl, 1, :, ?, →, B, :, B, +, C, →, C, :,
Dsz, A, :, Goto, 1, :, C, ÷, 1, 0 — 32 bytes

This program starts out by assigning a value of 10 to A. This is because value memory A will be used as a control variable. The next statement clears C to zero. After defining the location of label 1 (Lbl 1), the program then prompts for input of a value for B. The next statement adds the value of B to value memory C, and then stores the result in C. The next three statements say: "decrement the value in A, and if it is still greater than 0, jump back to label 1; otherwise divide the contents of C by 10".

Example 2 **To write a program that calculates at 1-second intervals the altitude of a ball thrown into the air at an initial velocity of Vm/sec and an angle of S°. The formula is expressed as: $h = V \cdot \sin St - \frac{1}{2}gt^2$, with g = 9.8. The effects of air resistance should be disregarded.**

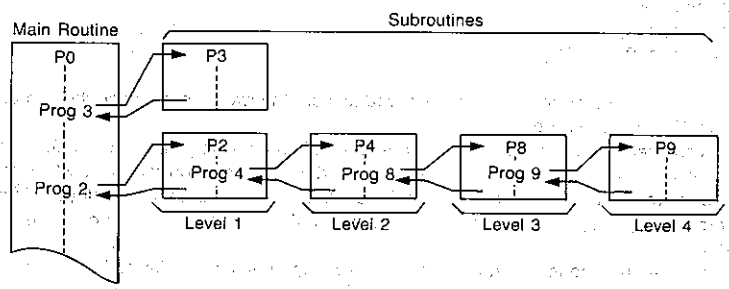
Program

Deg, :, 0, →, T, :, ?, →, V, :, ?, →, S, :,
Lbl, 1, :, Isz, T, :, V, ×, sin, S, ×, T, −,
9, •, 8, ×, T, x^2, ÷, 2, ◢, Goto, 1 — 38 bytes

With this program, the first statements specify the unit of angular measurement and clear T to 0. Then the initial velocity is prompted for V and the angle is prompted for S. Lbl 1 identifies the beginning of the repeat calculation.
The value stored in T is incremented by Isz T, and in this program the Isz command is used only for incrementation, without any comparison or decision being performed. Each time T is incremented, the formula is calculated and the altitude is displayed.

8-7 Using Subroutines

Up to this point, all of the programs we have seen were contained in a single program area. You can also jump between program areas, so that the resulting execution is made up of pieces in different areas. In such a case, the central program from which other areas are jumped to is called a "main routine". The areas jumped to from the main routine are called "subroutines".



To jump to another program area, use the "Prog" command (SHIFT PRGM F3 (Prg)), followed by the name of the program area you want to jump to (0 to 9, A to Z, r, θ).

Example **Prog 0 — Jumps to program area 0**
Prog T — Jumps to program area T

After the jump to the program area you specify, execution continues from the beginning of the subroutine stored in the specified program area. When end of the subroutine is reached, execution returns to the statement following the Prog command that initiated the subroutine.
You can jump from one subroutine to another, a procedure that is called "nesting". You can nest up to a maximum of 10 levels, and an error will occur (Ne ERROR) if you try to nest an 11th time. If you try to jump to a program area that does not contain a program, an error message (Go ERROR) will appear on the display.

Important

- The Goto command does not jump between program areas. A Goto command jumps to the label (Lbl) located inside the same program area.

■Subroutines Save Memory

Note the following two programs.

P0 Fix, 3, :, ?, →, A, :, 2, ×, √, 3, ×, A, x^2, ◢,
√, 2, ÷, 3, ×, A, ^, 3 — 23 bytes

P1 Fix, 3, :, ?, →, A, :, √, 3, ×, A, x^2, ◢,
√, 2, ÷, 1, 2, ×, A, ^, 3 — 22 bytes

If we input these two programs separately, they require a total of 45 bytes. But note that the underlined portions of these two programs are identical. This means that these parts can be stored as subroutines and called by both of the programs.
If we use subroutines, we get the following results.

Subroutines

P9 Fix, 3, :, ?, →, A, :, √, 3, ×, A, x^2 — 12 bytes
P8 √, 2, ÷, 3, ×, A, ^, 3 — 8 bytes

Main routines

P0 Prog, 9, :, Ans, ×, 2, ◢, Prog, 8 — 9 bytes
P1 Prog, 9, ◢, Prog, 8, :, Ans, ÷, 4 — 9 bytes

As you can see, the number of bytes required to store the two programs and the subroutines is 38, for a saving of 7 bytes.
When you execute the program in program area 0, it immediately jumps to P9 and executes the contents of that program area. At the end of P9, execution returns to P0 where the result produced by the subroutine in P9 is multiplied by 2 and then displayed. After you press the [EXE] key, execution jumps to P8, where the remainder of the program is executed.
With the main routine in program area P1, execution jumps immediately from program area P9. At the end of P9 execution returns to P1 where the P9 result is displayed. When you press [EXE], execution jumps again to P8. At the end of P8, execution returns to P1, where the result produced by P8 is divided by 4 and displayed.

8-8 Using Array Memory

In addition to the individual value memories, the unit gives you array memory capabilities. Note the following.

Value Memories	Array Memories
A	A[0] C[−2]
B	A[1] C[−1]
C	A[2] C[0]
D	A[3] C[1]
E	A[4] C[2]

Note

*You cannot use r or θ value memory as array memory.

As you can see, array memory names consist of an alphabetic character, followed by a *subscript* enclosed in brackets. The subscript is a value, either positive or negative, or a value memory that represents a value. If the value of 5 is assigned to value memory X, for example, the array memory A[X] would be equivalent to A[5].

■Array Memories Simplify Programming

Since the subscript of an array memory can be a value memory name, programming becomes more economical. Note the following.

Example **To write a program that assigns the values from 1 through 10 to memories A through J**

Using value memories

1, →, A, :, 2, →, B, :, 3, →, C, :, 4, →, D, :,
5, →, E, :, 6, →, F, :, 7, →, G, :, 8, →, H, :,
9, →, I, :, 1, 0, →, J — 40 bytes

Using array memories

0, →, Z, :, Lbl, 1, :, Z, +, 1, →, A, [, Z,], :,
Isz, Z, :, Z, <, 1, 0, ⇒, Goto, 1 — 26 bytes

As you can see, using array memories uses 14 fewer bytes. You get even more economy with the following program.

Example **To write a program that displays the contents of a memory specified by input**

Using value memories

Lbl, 1, :, ?, →, Z, :,
Z, =, 1, ⇒, A, ◢, Z, =, 2, ⇒, B, ◢,
Z, =, 3, ⇒, C, ◢, Z, =, 4, ⇒, D, ◢,
Z, =, 5, ⇒, E, ◢, Z, =, 6, ⇒, F, ◢,
Z, =, 7, ⇒, G, ◢, Z, =, 8, ⇒, H, ◢,
Z, =, 9, ⇒, I, ◢, Z, =, 1, 0, ⇒, J, ◢,
Goto, 1 — 70 bytes

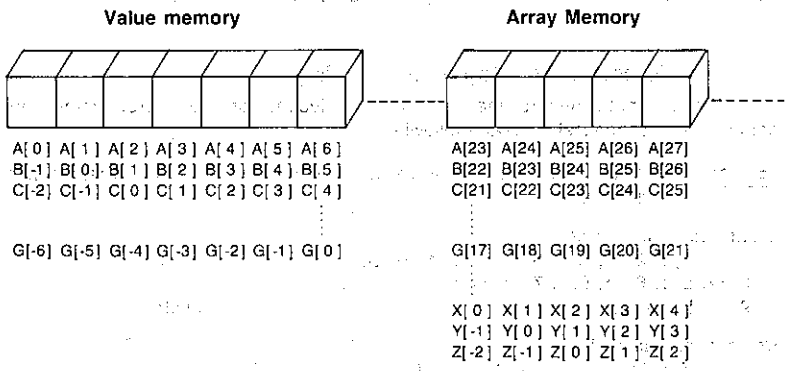
Using array memories

Lbl, 1, :, ?, →, Z, :, A, [, Z, −, 1,], ◢,
Goto, 1 — 16 bytes

With value memories, logical operations are used to test the input until the proper memory is found. With array memories, on the other hand, the specified memory is found immediately.

■Cautions When Using Array Memories

You should remember that array memories are actually based on value memories. Note the following relationship.


Value memory
Array Memory
A[0] A[1] A[2] A[3] A[4] A[5] A[6]
B[-1] B[0] B[1] B[2] B[3] B[4] B[5]
C[-2] C[-1] C[0] C[1] C[2] C[3] C[4]
G[-6] G[-5] G[-4] G[-3] G[-2] G[-1] G[0]
A[23] A[24] A[25] A[26] A[27]
B[22] B[23] B[24] B[25] B[26]
C[21] C[22] C[23] C[24] C[25]
G[17] G[18] G[19] G[20] G[21]
X[0] X[1] X[2] X[3] X[4]
Y[-1] Y[0] Y[1] Y[2] Y[3]
Z[-2] Z[-1] Z[0] Z[1] Z[2]

This means that you must be careful when using array memories that you do not overlap.

■Sample Programs That Use Array Memory

The following programs store x and y data in array memories. Whenever an x value is input, the corresponding y value is displayed. You can input a total of 15 sets of data.

Example 1 **With this version of the program, value memory A is used as a data control memory, while memory B is used for temporary storage of x data. The x data is stored in memories C[1] (value memory D) through C[15] (value memory R), while the y data is stored in memories C[16] (value memory S) through C[30] (value memory Z[7]).**

```
1, →, A, :, Defm, 7, :,
Lbl, 1, :, ?, →, C, [, A, ], :,
?, →, C, [, A, +, 1, 5, ], :,
Isz, A, :, A, =, 1, 6, ⇒, Goto, 2, :, Goto, 1, :,
Lbl, 2, :, 1, 5, →, A, :, ?, →, B, :,
B, =, 0, ⇒, Goto, 5, :,
Lbl, 3, :, B, =, C, [, A, ], ⇒, Goto, 4, :,
Dsz, A, :, Goto, 3, :, Goto, 2, :,
Lbl, 4, :, C, [, A, +, 1, 5, ], ◢, Goto, 2, :,
Lbl, 5                                          98 bytes
```


The above program uses value memories as follows:

x data

C[1]	C[2]	C[3]	C[4]	C[5]	C[6]	C[7]	C[8]	C[9]	C[10]
D	E	F	G	H	I	J	K	L	M
C[11]	C[12]	C[13]	C[14]	C[15]					
N	O	P	Q	R					

y data

C[16]	C[17]	C[18]	C[19]	C[20]	C[21]	C[22]	C[23]	C[24]	C[25]
S	T	U	V	W	X	Y	Z	Z(1)	Z(2)
C[26]	C[27]	C[28]	C[29]	C[30]					
Z(3)	Z(4)	Z(5)	Z(6)	Z(7)					

Example 2 **This version is identical to Example 1, except that a different letter is used for the x and y data names.**

```
1, →, A, :, Defm, 7, :,
Lbl, 1, :, ?, →, C, [, A, ], :,
?, →, R, [, A, ], :,
Isz, A, :, A, =, 1, 6, ⇒, Goto, 2, :, Goto, 1, :,
Lbl, 2, :, 1, 5, →, A, :, ?, →, B, :,
B, =, 0, ⇒, Goto, 5, :,
Lbl, 3, :, B, =, C, [, A, ], ⇒, Goto, 4, :,
Dsz, A, :, Goto, 3, :, Goto, 2, :,
Lbl, 4, :, R, [, A, ], ◢, Goto, 2, :,
Lbl, 5                                          92 bytes
```

This above program uses value memories as follows:

x data

C[1]	C[2]	C[3]	C[4]	C[5]	C[6]	C[7]	C[8]	C[9]	C[10]
D	E	F	G	H	I	J	K	L	M
C[11]	C[12]	C[13]	C[14]	C[15]					
N	O	P	Q	R					

y data

R[1]	R[2]	R[3]	R[4]	R[5]	R[6]	R[7]	R[8]	R[9]	R[10]
S	T	U	V	W	X	Y	Z	Z(1)	Z(2)
R[11]	R[12]	R[13]	R[14]	R[15]					
Z(3)	Z(4)	Z(5)	Z(6)	Z(7)					

Note that in the above two programs the Defm command was necessary to increase the number of value memories.

8-9 Displaying Text Messages

Text, numbers, and symbols can be displayed by programs as messages that prompt input, etc. Note the following example.

Statement	Display
Without text ? → X	?
With text "X=" ? → X	X=?

As you can see, the text prompt makes it much easier to understand what input is required by the program.

Messages can also be used to explain the meaning of a displayed result.

Example

```
Lbl, 0, :, ", N, =, ", ?, →, B, ~, C, :,
0, →, A, :,
Lbl, 1, :, C, ÷, 2, →, C, :, Frac, C, ×, 0, ⇒, Goto, 3, :,
Isz, A, :, C, =, 1, ⇒, Goto, 2, :, Goto, 1, :,
Lbl, 2, :, ", X, =, ", ◢, A, ◢, Goto, 0, :,
Lbl, 3, :, ", N, O, ", ◢, Goto, 0                    70 bytes
```

This program prompts for input of a value. If the input value is equivalent to 2^x, it displays the value of x. If the input value is not equivalent to 2^x, it displays the message "NO".

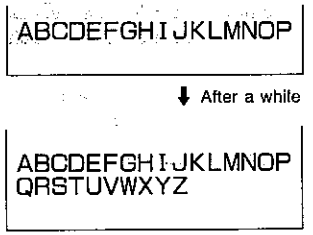
Important

Be sure to follow the message with a display result command if there is another statement following the message.

Assuming that the program is stored in P2:

F1(RUN)	N=?
4 0 9 6 EXE	X=
EXE	12.
EXE	N=?
3 1 2 4 EXE	NO
EXE	N=?
5 1 2 EXE	X=
EXE	9.

Text that is longer than 16 characters is displayed in two lines. When text is at the bottom of the display, the entire screen scrolls upwards.



8-10 Using Matrices in Programs

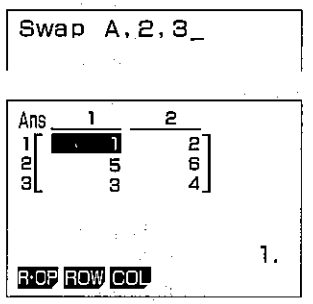
You can use matrix row operations (page 104) in programs to swap rows, calculate scalar products, add scalar products to other rows, and add two rows.

• To swap two rows

Example **To swap rows two and three in the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Swap, A, ·, 2, ·, 3 7 bytes



EXIT EXIT F1(RUN)
F4(LIST)
F1(EDIT)

• To calculate a scalar product for a row

Example To calculate a scalar product of row 2 of the following matrix (Matrix A), by multiplying each element by 4.

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

* Row, 4, ⁄, A, ⁄, 2 — 7 bytes

```
*Row 4,A,2_
```

EXIT EXIT F1(RUN)
F4(LIST)
F1(EDIT)

```
Ans   1    2
1[    1    2
2     12   16
3]    5    6
                1.
R·OP ROW COL
```

• To add the scalar product of one row to another row

Example To calculate a scalar product of row 2 of the following matrix (Matrix A), by multiplying each element by 4, and then add the results to row 3.

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

* Row+, 4, ⁄, A, ⁄, 2, ⁄, 3 — 9 bytes

```
*Row+ 4,A,2,3_
```

EXIT EXIT F1(RUN)
F4(LIST)
F1(EDIT)

```
Ans   1    2
1[    1    2
2     3    4
3]    17   22
                1.
R·OP ROW COL
```


• To add one row to another

Example To add row 2 to row 3 in the following matrix (Matrix A), and store the result in row 3.

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Row+, A, ⁄, 2, ⁄, 3 — 9 bytes

```
Row+ A,2,3_
```

EXIT EXIT F1(RUN)
F4(LIST)
F1(EDIT)

```
Ans   1    2
1[    1    2
2     3    4
3]    8    10
                1.
R·OP ROW COL
```

8-11 Using the Graph Function in Programs

By using the graph function in programs, you can graphically represent long, complex equations and overdraw graphs a number of times. All graph commands (except the Trace Function) can be used in programs. You can also specify range parameters in programs.

Example **To graphically represent the number of solutions (real roots) that satisfy both of the following equations**

$$y = x^4 - x^3 - 24x^2 + 4x + 80$$
$$y = 10x - 30$$

Use the following range parameters.

```
Xmin : −10
 max: 10
 scl : 2
Ymin : −120
 max: 150
 scl : 50
```

First, program the range parameters. Note that parameters are separated by commas. Press EXE at the end.

Range, (−), 1, 0, ⁄, 1, 0, ⁄, 2, ⁄, (−), 1, 2, 0, ⁄, 1, 5, 0, ⁄, 5, 0

Next, program the equation for the first graph. Press EXE at the end.

Graph, X, ^, 4, −, X, ^, 3, −, 2, 4, X, x^2, +, 4, X, +, 8,

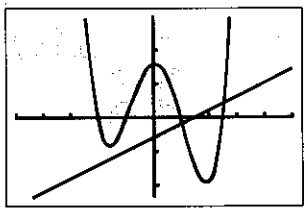
Finally, program the equation for the second graph.

Graph, 1, 0, X, −, 3, 0 Total: 49 bytes

```
Range −10,10,2,−
120,150,50↵
Graph Y=X^4−X^3−
24X²+4X+80↵
Graph Y=10X−30_
```

The above program should produce this graph when you execute it.

EXIT F1(RUN)



You could use a display result command (◢) in place of the EXE operation at the end of the first equation. This will cause execution to stop after the first graph is drawn. To resume execution, press EXE.

Chapter 9

Data Communications

9-1 Connecting Two fx-7700GE Units

9-2 Connecting the fx-7700GE with a Personal Computer

9-3 Before Starting Data Communications

9-4 Setting Communications Parameters

9-5 Using ALL to Send All Data

9-6 Using PROGRAM to Send Program Data

9-7 Using FUNCTION MEM to Send Function Memory Data

9-8 Using MATRIX to Send Matrix Memory Data

9-9 Using STATISTICS to Send Statistical Memory Data

9-10 Using VARIABLE MEM to Send Value Memory Data

9-11 Using RANGE to Send Graph Range Parameters

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9-13 Using GRAPH FUNCTION to Send Graph Function Memory Data

9-14 Using EQUATION to Send Equation Data

9-15 Using BACK UP to Send All Mode Settings and Memory Data

9-16 Screen Copy Function

9-17 Data Communications Precautions

Chapter 9 Data Communications

This chapter tells you everything you need to know to transfer programs between the fx-7700GE and another CASIO Power Graphic unit (fx-7700GE, fx-7700GB, fx-8700GB), connected with an optionally available SB-62 cable. To transfer data between an fx-7700GE unit and a personal computer, you will need to purchase the separately available CASIO FA-121 Ver. 2.0 Interface Unit.

■General Procedure

The following is the general procedure to follow when performing data communications. Details of each procedures are presented in the following sections of this chapter.

- Though you can transfer data between the fx-7700GE and another fx-7700GE, an fx-7700GB or an fx-8700GB, all of the examples in this manual cover data transfer with another fx-7700GE only.

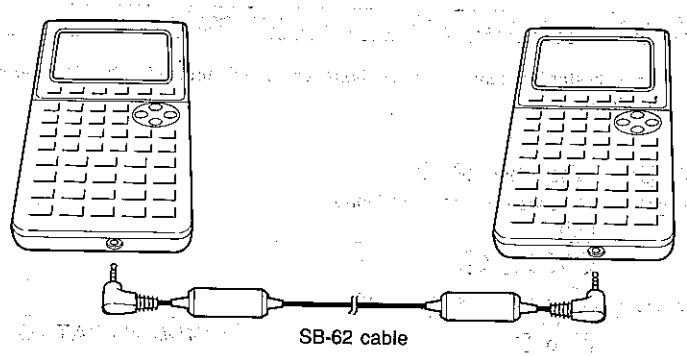
1. Connect the two units.
2. Set up the two units with the same parameters.
3. Set up one unit to send, and the other unit to receive.
4. On the receive unit, specify the data to be received and put the unit into receive standby.
5. On the send unit, specify the data to be sent and start the send operation.

9-1 Connecting Two fx-7700GE Units

The following procedure describes how to connect two Power Graphic units with an optional SB-62 connecting cable for transfer of programs between them.

■To Connect Two fx-7700GE Units

1. Check to make sure that the power of both fx-7700GE units is off.
2. Remove the covers from the connectors of the two Power Graphic units.
   - Be sure you keep the connector covers in a safe place so you can replace them after you finish your program communications.
3. Connect the two units using the SB-62 cable.



SB-62 cable

Important

- Keep the connectors of the fx-7700GE covered when you are not using them.

9-2 Connecting the fx-7700GE with a Personal Computer

To transfer data between the fx-7700GE and a personal computer, you must connect them through a separately available CASIO FA-121 Ver. 2.0 Interface Unit.

For details on operation, the types of computer that can be connected, and handware limitations, see the user's manual that comes with the FA-121 Ver. 2.0.

■To Connect the fx-7700GE with a Personal Computer

1. Check to make sure that the power of the Power Graphic and the personal computer is off.
2. Connect the personal computer to the FA-121 Ver. 2.0 Interface Unit.
3. Remove the cover from the connector of the fx-7700GE.
   - Be sure you keep the connector cover in a safe place so you can replace it after you finish your program communications.
4. Connect the fx-7700GE to the FA-121 Ver. 2.0 Interface Unit.
5. Switch on the power of the fx-7700GE, followed by the personal computer.
   - After you finish program communications, switch off power in the sequence: fx-7700GE first, and then the personal computer. Finally, disconnect the equipment.

9-3 Before Starting Data Communications

Before actually starting data communications, you should first enter the LINK Mode from the Main Menu.

■To Enter the LINK Mode

Highlight the **LINK** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] or [9] to display the LINK Mode.

[EXE] or [9]

```
COMMUNICATION

 PARITY:EVEN
 BPS    :9600
F1:TRANSMIT
F2:RECEIVE
F6:PARAMETERS
TRN RCV          PRM
```

[F1] [F2] [F6]

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

[F1](TRN) ..... Transmit
[F2](RCV) ..... Receive
[F6](PRM) ..... Parameter settings

■About the Data Type Selection Screen

Whenever you press [F1](TRN) to send data or [F2](RCV) to receive data, a data type selection screen appears on the display.

Send Unit

[F1](TRN)

```
TRANSMIT DATA
▶ALL
 Program
 Function Mem
 Matrix
 Statistics
 Variable Mem
 Range                ↓
```

Pointer Indicates more below

Receive Unit

[F2](RCV)

```
RECEIVE DATA
▶ALL
 Program
 Function Mem
 Matrix
 Statistics
 Variable Mem
 Range                ↓
```


The following table describes what each of these items means. You will learn later how to make a selection using these screens.

Selection	Meaning
ALL	All data from PROGRAM to EQUATION
Program	Program data
Function Mem	Function memory contents
Matrix	Matrix memory contents
Statistics	Single-variable and paired-variable statistical data
Variable Mem	Value memory and extended memory contents
Range	Graph range parameters
Factor	Factor function zoom ratios
Graph Function	Graph functions
Equation	Equation coefficients
Back Up	All memory contents

Note

- If the selections you make on the send unit and receive unit do not match, a TRANSMIT ERROR will be generated on the sender and a RECEIVE ERROR will be generated on the receiver.

9-4 Setting Communications Parameters

Before you can perform data communications, you must first set up certain hardware parameters to make sure that the two units are able to understand each other. The parameters of the sender and the receiver must be identical for them to be able to communicate correctly. There are two hardware parameters that you can set.

Parameter	Settings
Parity	EVEN ODD NONE
Speed (BPS)	12 (1200) 24 (2400) 48 (4800) 96 (9600)

■To Set fx-7700GE Parameters

Starting from the LINK Mode:

[F6](PRM)

Pointer

```
PARAMETERS
▮PARITY
  EVEN ODD NONE
 BPS (×100)
   12 24 48 96
TO SELECT:[↓][↑]
          [←][→]
TO SET    :[EXE]
```

*The parameters that are currently set are highlighted on the display.

The pointer indicate which parameter you can change. Use ◀ and ▶ to move the highlighting and change the parameter where the pointer is located.

▶▶

```
PARAMETERS
▮PARITY
  EVEN ODD NONE
 BPS (×100)
   12 24 48 96
TO SELECT:[↓][↑]
          [←][→]
TO SET    :[EXE]
```

Use ▲ and ▼ to move the pointer up and down.
After the parameters are highlighted the way you want, press [EXE] to store them.

[EXE]

```
COMMUNICATION

 PARITY:NONE
 BPS   :9600
F1:TRANSMIT
F2:RECEIVE
F6:PARAMETERS
TRN RCV        PRM
```

•To abort the parameter setting procedure and return the settings to what they were before you changed them, press [AC] before pressing [EXE] to strore the parameters.

9-5 Using ALL to Send All Data

The following procedures show how to send all data, from Program to Equation from one fx-7700GE unit to another.

Warning!

The following operation causes data in the seven applicable memory areas (program, function memory, matrix memory, single-variable and paired-variable statistical data memory, value and extended memory, graph function memory, and equation coefficient memory) of the receiving unit to be replaced by the received data. Make sure that you do not need the data stored in the receiving unit before you start this operation.

• To send ALL data

Send Unit

Starting from the LINK Mode, press the function key to enter the send mode.

F1(TRN)

```
TRANSMIT DATA
▶ALL
 Program
 Function Mem
 Matrix
 Statistics
 Variable Mem
 Range                ↓
```

Make sure that the pointer is located at ALL, and press EXE to specify it as the data type.

EXE

```
==TRANSMIT==
ALL DATA

YES                  NO
```

F1 F6

Press F1(YES) to start the send operation, or F6(NO) to abort without sending anything.

F1(YES)

```
==TRANSMITTING==

ALL DATA

TO STOP   :[AC]
```

*Pressing AC interrupts the send operation and returns to the LINK Mode.

Receive Unit

Starting from the LINK Mode, press the function key to enter the receive mode.

F2(RCV)

```
RECEIVE DATA
▶ALL
 Program
 Function Mem
 Matrix
 Statistics
 Variable Mem
 Range                ↓
```

Make sure that the pointer is located at ALL, and press EXE to specify it as the data type.

EXE

```
==RECEIVE==
ALL DATA

YES                  NO
```

F1 F6

Press F1(YES) start the receive operation, or F6(NO) to abort without receiving anything.

F1(YES)

```
==RECEIVING==

ALL DATA

TO STOP   :[AC]
```

*Pressing AC interrupts the receive operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

ALL DATA

    PRESS [AC]
```

*Press AC to return to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

ALL DATA

    PRESS [AC]
```

9-6 Using PROGRAM to Send Program Data

The following procedures show how to send program data from one fx-7700GE unit to another. You can specify one specific program or all programs for the communication operation.

• To send all PROGRAM data

Send Unit

Starting from the LINK Mode, press F1(TRN) to enter the send mode.

Move the pointer to Program, and press EXE to specify it as the data type.

▼ EXE

```
==TRANSMIT==
PROGRAM

ALL ONE
```

F1 F2

Receive Unit

Starting from the LINK Mode, press F2(RCV) to enter the receive mode.

Move the pointer to Program, and press EXE to specify it as the data type.

▼ EXE

```
==RECEIVE==
PROGRAM

ALL ONE
```

F1 F2

Press [F1](ALL) to specify all programs.

[F1](ALL)

```
==TRANSMIT==

ALL PROGRAMS


YES          NO
F1           F6
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

ALL PROGRAMS


TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

ALL PROGRAMS


   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

Press [F1](ALL) to specify all programs.

[F1](ALL)

```
==RECEIVING==

ALL PROGRAMS


TO STOP   :[AC]
```

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

ALL PROGRAMS


   PRESS [AC]
```


• To send a specific program

Send Unit

[F1](TRN)

[▼][EXE]

Press [F2](ONE) to specify one program.

[F2](ONE)

```
==TRANSMIT==
TO SELECT:[↓][↑]
TO START :[EXE]
P0 'CYCLOID'
P1 empty
P2 'MATHEMATICS'
P3 empty
```

Use the [▲] and [▼] keys to move the pointer to the right of the program area you want to send. After you select the program area press [EXE] to start the send operation.

[▼][▼][EXE]

```
==TRANSMITTING==

TO STOP   :[AC]
P0 'CYCLOID'
P1 empty
P2 'MATHEMATICS'
P3 empty
```

•Pressing [AC] interrupts the send operation and returns to the LINK Mode.

After the send operation is complete, the program selection display appears, so you can send another program if you want.

Receive Unit

[F2](RCV)

[▼][EXE]

Press [F2](ONE) to specify one program.

[F2](ONE)

```
==RECEIVE==
TO SELECT:[↓][↑]
TO START :[EXE]
P0 'FORMULA'
P1 empty
P2 empty
P3 empty
```

Use the [▲] and [▼] keys to move the pointer to the right of the program area where you want the received program to be stored. After you select the program area press [EXE] to start the receive operation.

[▼][EXE]

```
==RECEIVING==

TO STOP   :[AC]
P0 'FORMULA'
P1 empty
P2 empty
P3 empty
```

•Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

After the receive operation is complete, the program area selection display appears, so you can receive another program if you want.

9-7 Using FUNCTION MEM to Send Function Memory Data

The following procedures show how to send function memory data from one fx-7700GE unit to another. You can specify one specific function or all functions for the communication operation.

• To send all FUNCTION MEM data

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Function Mem, and press [EXE] to specify it as the data type.

▼▼[EXE]

```
==TRANSMIT==
FUNCTION MEM


ALL ONE
```

[F1] [F2]

Press [F1](ALL) to specify all functions.

[F1](ALL)

```
==TRANSMIT==

ALL FUNCTION MEM


YES          NO
```

[F1] [F6]

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Function Mem, and press [EXE] to specify it as the data type.

▼▼[EXE]

```
==RECEIVE==
FUNCTION MEM


ALL ONE
```

[F1] [F2]

Press [F1](ALL) to specify all functions.

[F1](ALL)

```
==RECEIVING==

ALL FUNCTION MEM


TO STOP  :[AC]
```


Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

ALL FUNCTION MEM


TO STOP  :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

ALL FUNCTION MEM


  PRESS [AC]
```

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

ALL FUNCTION MEM


  PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

• To send a specific function

Send Unit

[F1](TRN)

▼▼[EXE]

Press [F2](ONE) to specify one function.

[F2](ONE)

```
==TRANSMIT==
TO SELECT:[↓][↑]
TO START :[EXE]
▮f1:log X
 f2:
 f3:log (x+1)
 f4:
 f5:
```

Receive Unit

[F2](RCV)

▼▼[EXE]

Press [F2](ONE) to specify one function.

[F2](ONE)

```
==RECEIVE==
TO SELECT:[↓][↑]
TO START :[EXE]
▮f1:cos X
 f2:
 f3:
 f4:
 f5:(X+2)(2X-5)
```

Use the ▲ and ▼ keys to move the pointer to the left of the function memory area you want to send. After you select the function memory press EXE to start the send operation.

▼▼EXE

```
==TRANSMITTING==

TO STOP   :[AC]
 f1:log X
 f2:
■f3:log (X+1)
 f4:
 f5:
```

*Pressing AC interrupts the send operation and returns to the LINK Mode.

After the send operation is complete, the function memory selection display appears, so you can send another function if you want.

Use the ▲ and ▼ keys to move the pointer to the left of the function memory area where you want the received function to be stored. After you select the function memory press EXE to start the receive operation.

▼EXE

```
==RECEIVING==

TO STOP   :[AC]
 f1:cos X
■f2:
 f3:
 f4:
 f5:(x+2)(2x-5)
```

*Pressing AC interrupts the receive operation and returns to the LINK Mode.

After the receive operation is complete, the function memory selection display appears, so you can receive another function if you want.

9-8 Using MATRIX to Send Matrix Memory Data

The following procedures show how to send matrix memory data from one fx-7700GE unit to another. You can specify one specific matrix or all matrices for the communication operation.

• To send all MATRIX data

Send Unit

Starting from the LINK Mode, press F1(TRN) to enter the send mode.

Move the pointer to Matrix, and press EXE to specify it as the data type.

▼▼▼EXE

```
==TRANSMIT==
MATRIX


ALL ONE
```

F1 F2

Receive Unit

Starting from the LINK Mode, press F2(RCV) to enter the receive mode.

Move the pointer to Matrix, and press EXE to specify it as the data type.

▼▼▼EXE

```
==RECEIVE==
MATRIX


ALL ONE
```

F1 F2

Press F1(ALL) to specify all matrix data.

F1(ALL)

```
==TRANSMIT==

ALL MATRICES


YES          NO
```

F1 F6

Press F1(YES) to start the send operation, or F6(NO) to abort without sending anything.

F1(YES)

```
==TRANSMITTING==

ALL MATRICES


TO STOP   :[AC]
```

*Pressing AC interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

ALL MATRICES


  PRESS [AC]
```

*Press AC to return to the LINK Mode.

Press F1(ALL) to specify all matrix data.

F1(ALL)

```
==RECEIVING==

ALL MATRICES


TO STOP   :[AC]
```

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing AC interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

ALL MATRICES


  PRESS [AC]
```

• To send a specific matrix

Send Unit

[F1](TRN)

[▼][▼][▼][EXE]

Press [F2](ONE) to specify one matrix.

[F2](ONE)

```
==TRANSMIT==
TO SELECT:[↓][↑]
TO START :[EXE]
▶Mat A  :None
 Mat B  :2×2
 Mat C  :3×3
 Mat D  :None
 Mat E  :None
```

Use the [▲] and [▼] keys to move the pointer to the left of the matrix memory area you want to send. After you select the matrix memory press [EXE] to start the send operation.

[▼][▼][EXE]

```
==TRANSMITTING==

TO STOP  :[AC]
 Mat A  :None
 Mat B  :2×2
▶Mat C  :3×3
 Mat D  :None
 Mat E  :None
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

After the send operation is complete, the matrix memory selection display appears, so you can send another matrix if you want.

Receive Unit

[F2](RCV)

[▼][▼][▼][EXE]

Press [F2](ONE) to specify one matrix.

[F2](ONE)

```
==RECEIVE==
TO SELECT:[↓][↑]
TO START :[EXE]
▶Mat A  :None
 Mat B  :None
 Mat C  :None
 Mat D  :2×2
 Mat E  :3×3
```

Use the [▲] and [▼] keys to move the pointer to the left of the matrix memory area where you want the received matrix to be stored. After you select the matrix memory press [EXE] to start the receive operation.

[▼][EXE]

```
==RECEIVING==

TO STOP  :[AC]
 Mat A  :None
▶Mat B  :None
 Mat C  :None
 Mat D  :2×2
 Mat E  :3×3
```

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

After the receive operation is complete, the matrix memory selection display appears, so you can receive another matrix if you want.

9-9 Using STATISTICS to Send Statistical Memory Data

The following procedures show how to send statistical memory data from one fx-7700GE unit to another. You can specify single-variable (standard deviation) or paired-variable (regression) data for the communication operation.

• To send single-variable (standard deviation) data

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Statistics, and press [EXE] to specify it as the data type.

[▼][▼][▼][▼][EXE]

```
==TRANSMIT==
STATISTICS


 SD  REG
```

[F1] [F2]

Press [F1](SD) to specify single-variable (standard deviation) data.

[F1](SD)

```
==TRANSMIT==

SD DATA


YES        NO
```

[F1] [F6]

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Statistics, and press [EXE] to specify it as the data type.

[▼][▼][▼][▼][EXE]

```
==RECEIVE==
STATISTICS


 SD  REG
```

[F1] [F2]

Press [F1](SD) to specify single-variable (standard deviation) data.

[F1](SD)

```
==RECEIVING==

SD DATA


TO STOP  :[AC]
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

SD DATA

TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

• To send paired-variable (regression)

Send Unit

[F1](TRN)

[▼][▼][▼][▼][EXE]

Press [F2](REG) to specify paired-variable (regression) data.

[F2](REG)

```
==TRANSMIT==

REG DATA

YES          NO
 F1          F6
```

Receive Unit

[F2](RCV)

[▼][▼][▼][▼][EXE]

Press [F2](REG) to specify paired-variable (regression) data.

[F2](REG)

```
==RECEIVING==

REG DATA

TO STOP   :[AC]
```


Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

REG DATA

TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

REG DATA

   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

REG DATA

   PRESS [AC]
```

9-10 Using VARIABLE MEM to Send Value Memory Data

The following procedures show how to send value memory data from one fx-7700GE unit to another. You can specify all variable memories, variable memories from A through Z only, or expanded variable memories only.

• To send all VARIABLE MEM data

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Variable Mem, and press [EXE] to specify it as the data type.

▼▼▼▼▼[EXE]

```
==TRANSMIT==
VARIABLE MEM


ALL A~Z Dfm
```

[F1] [F2] [F3]

Press [F1](ALL) to specify all value memories.

[F1](ALL)

```
==TRANSMIT==

ALL VARIABLE MEM


YES                NO
```

[F1] [F6]

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

ALL VARIABLE MEM


TO STOP   :[AC]
```

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Variable Mem, and press [EXE] to specify it as the data type.

▼▼▼▼▼[EXE]

```
==RECEIVE==
VARIABLE MEM


ALL A~Z Dfm
```

[F1] [F2] [F3]

Press [F1](ALL) to specify all value memories.

[F1](ALL)

```
==RECEIVING==

ALL VARIABLE MEM


TO STOP   :[AC]
```

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

ALL VARIABLE MEM

   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

ALL VARIABLE MEM

   PRESS [AC]
```

• To send data from variable memories A through Z only

Send Unit

[F1](TRN)

▼▼▼▼▼[EXE]

Press [F2](A~Z) to specify value memories A through Z only.

[F2](A~Z)

```
==TRANSMIT==

A~Z VARIABLE MEM


YES                NO
```

[F1] [F6]

Receive Unit

[F2](RCV)

▼▼▼▼▼[EXE]

Press [F2](A~Z) to specify value memories A through Z only.

[F2](A~Z)

```
==RECEIVING==

A~Z VARIABLE MEM


TO STOP   :[AC]
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

A~Z VARIABLE MEM

TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

A~Z VARIABLE MEM

    PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

A~Z VARIABLE MEM

    PRESS [AC]
```

● To send data from extended memories only

Send Unit

[F1](TRN)

[▼][▼][▼][▼][▼][EXE]

Press [F3](Dfm) to specify extended value memories only.

[F3](Dfm)

```
==TRANSMIT==

DEFINED MEMORIES

YES                NO
F1                 F6
```

Receive Unit

[F2](RCV)

[▼][▼][▼][▼][▼][EXE]

Press [F3](Dfm) to specify extended value memories only.

[F3](Dfm)

```
==RECEIVING==

DEFINED MEMORIES

TO STOP   :[AC]
```


Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

DEFINED MEMORIES

TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

DEFINED MEMORIES

    PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

DEFINED MEMORIES

    PRESS [AC]
```

9-11 Using RANGE to Send Graph Range Parameters

The following procedures show how to send graph range parameters from one fx-7700GE unit to another.

● To send RANGE data

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Range, and press [EXE] to specify it as the data type.

▼▼▼▼▼▼[EXE]

```
==TRANSMIT==
RANGE

YES          NO
F1           F6
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

RANGE

TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

RANGE

   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Range, and press [EXE] to specify it as the data type.

▼▼▼▼▼▼[EXE]

```
==RECEIVE==
RANGE

YES          NO
F1           F6
```

Press [F1](YES) start the receive operation, or [F6](NO) to abort without receiving anything.

[F1](YES)

```
==RECEIVING==

RANGE

TO STOP   :[AC]
```

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

RANGE

   PRESS [AC]
```


9-12 Using FACTOR to Send Graph Range Parameters

The following procedures show how to send factor data for graph zoom operations from one fx-7700GE unit to another.

● To send FACTOR data

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Factor, and press [EXE] to specify it as the data type.

▼▼▼▼▼▼▼[EXE]

```
==TRANSMIT==
FACTOR

YES          NO
F1           F6
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

FACTOR

TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Factor, and press [EXE] to specify it as the data type.

▼▼▼▼▼▼▼[EXE]

```
==RECEIVE==
FACTOR

YES          NO
F1           F6
```

Press [F1](YES) start the receive operation, or [F6](NO) to abort without receiving anything.

[F1](YES)

```
==RECEIVING==

FACTOR

TO STOP   :[AC]
```

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

FACTOR

    PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

FACTOR

    PRESS [AC]
```

9-13 Using GRAPH FUNCTION to Send Graph Function Memory Data

The following procedures show how to send graph function memory data from one fx-7700GE unit to another. You can specify one specific function or all functions for the communication operation.

• To send all GRAPH FUNCTION data

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Graph Function, and press [EXE] to specify it as the data type.

▼▼▼▼▼▼▼▼▼

[EXE]

```
==TRANSMIT==
GRAPH FUNCTION


ALL ONE
```

[F1] [F2]

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Graph Function, and press [EXE] to specify it as the data type.

▼▼▼▼▼▼▼▼▼

[EXE]

```
==RECEIVE==
GRAPH FUNCTION


ALL ONE
```

[F1] [F2]

Press [F1](ALL) to specify all functions.

[F1](ALL)

```
==TRANSMIT==

ALL GRAPH FUNC


YES          NO
```

[F1] [F6]

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

ALL GRAPH FUNC


TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

ALL GRAPH FUNC

    PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

Press [F1](ALL) to specify all functions.

[F1](ALL)

```
==RECEIVING==

ALL GRAPH FUNC


TO STOP   :[AC]
```

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

ALL GRAPH FUNC

    PRESS [AC]
```

• To send a specific function

Send Unit

[F1](TRN)

▼▼▼▼▼▼▼▼▼

[EXE]

Press [F2](ONE) to specify one function.

[F2](ONE)

```
==TRANSMIT==
TO SELECT:[↓][↑]
TO START :[EXE]
▮Y1:
 Y2:sin X
 Y3:cos X
 Y4:
 Y5:
```

Use the ▲ and ▼ keys to move the pointer to the left of the function memory area you want to send. After you select the function memory press [EXE] to start the send operation.

▼▼[EXE]

```
==TRANSMITTING==

TO STOP  :[AC]
 Y1:
 Y2:sin X
▮Y3:cos X
 Y4:
 Y5:
```

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

After the send operation is complete, the function memory selection display appears, so you can send another function if you want.

Receive Unit

[F2](RCV)

▼▼▼▼▼▼▼▼▼

[EXE]

Press [F2](ONE) to specify one function.

[F2](ONE)

```
==RECEIVE==
TO SELECT:[↓][↑]
TO START :[EXE]
▮Y1:
 Y2:
 Y3:log X
 Y4:log (x+1)
 Y5:
```

Use the ▲ and ▼ keys to move the pointer to the left of the function memory area where you want the received function to be stored. After you select the function memory press [EXE] to start the receive operation.

▼[EXE]

```
==RECEIVING==

TO STOP  :[AC]
 Y1:
▮Y2:
 Y3:log X
 Y4:log (x+1)
 Y5:
```

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

After the receive operation is complete, the function memory selection display appears, so you can receive another function if you want.

9-14 Using EQUATION to Send Equation Data

The following procedures show how to send equation memory data from one fx-7700GE unit to another. You can specify linear equations with two or three unknowns, or quadratic equation coefficient values for the communication operation.

• To send linear equation data

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Equation, and press [EXE] to specify it as the data type.

▼▼▼▼▼▼▼▼▼

▼[EXE]

```
==TRANSMIT==
EQUATION


SIM FLY
```

[F1] [F2]

Press [F1](SIM) to specify simultaneous equations (with two or three unknowns).

[F1](SIM)

```
==TRANSMIT==

SIMULT EQU


YES          NO
```

[F1] [F6]

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Equation, and press [EXE] to specify it as the data type.

▼▼▼▼▼▼▼▼▼

▼[EXE]

```
==RECEIVE==
EQUATION


SIM PLY
```

[F1] [F2]

Press [F1](SIM) to specify simultaneous equations (with two or three unknowns).

[F1](SIM)

```
==RECEIVING==

SIMULT EQU


TO STOP  :[AC]
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

SIMULT EQU

TO STOP  :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

• To send quadratic equation coefficient data

Send Unit

[F1](TRN)

▼▼▼▼▼▼▼▼▼[EXE]

Press [F2](PLY) to specify quadratic equation coefficient data.

[F2](PLY)

```
==TRANSMIT==

POLY EQU

YES          NO
F1           F6
```

Receive Unit

[F2](RCV)

▼▼▼▼▼▼▼▼▼[EXE]

Press [F2](PLY) to specify quadratic equation coefficient data.

[F2](PLY)

```
==RECEIVING==

POLY EQU

TO STOP  :[AC]
```


Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

POLY EQU

TO STOP  :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE

POLY EQU

  PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE

POLY EQU

  PRESS [AC]
```

9-15 Using BACK UP to Send All Mode Settings and Memory Data

The following procedures show how to send all mode settings and memory data from one fx-7700GE unit to another. This operation is helpful if you wish to back up memory contents using another unit.

Warning!

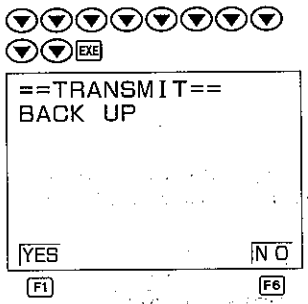
If any data communication problem occurs during data communications, the receiving unit is automatically reset. To avoid this, make sure that all connections are secure and take care to avoid anything that might possibly cause a data communication problem.

• To back up all data

Send Unit

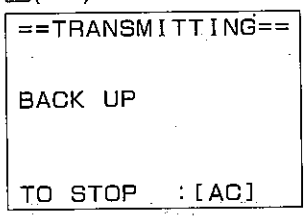
Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Back Up, and press [EXE] to specify it as the data type.



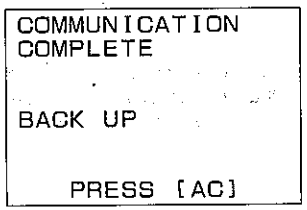
Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)



*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

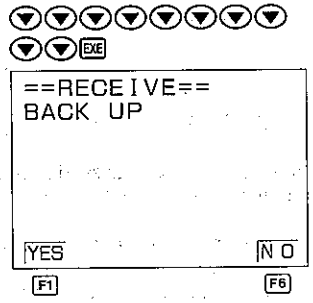


*Press [AC] to return to the LINK Mode.

Receive Unit

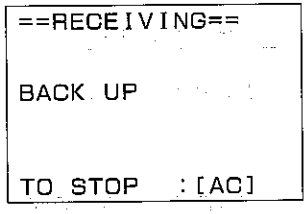
Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Back Up, and press [EXE] to specify it as the data type.



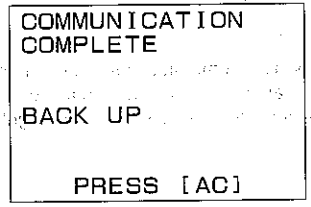
Press [F1](YES) to start the receive operation, or [F6](NO) to abort without receiving anything.

[F1](YES)



*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.



9-16 Screen Copy Function

The following procedure sends a bit mapped screen shot of the display to a connected computer.

■To Copy the Screen

1. Connect the unit to a personal computer (page 225).
2. Display the set up screen and specify COPY as the function of the [M-DISP] key (M-DISP/COPY Mode).
3. Display the screen you want to copy and press the [M-DISP] key.

You cannot send the following types of screens to a computer.

- The screen that appears while a data communication operation is in progress.
- A screen that appears while a calculation is in progress.
- The screen that appears following the reset operation.
- The low battery message.

Note also that the flashing cursor is not included in the screen image that is sent to the computer.

9-17 Data Communications Precautions

Note the following precautions whenever you perform data communications.

- A TRANSMIT ERROR occurs whenever you try to send data to a receiving unit that is not yet standing by to receive data. When this happens, press [AC] to clear the error and try again, after setting up the receiving unit to receive data.
- A RECEIVE ERROR occurs whenever the receiving unit does not receive any data approximately six minutes after it is set up to receive data. When this happens, press [AC] to clear the error.
- A TRANSMIT ERROR or RECEIVE ERROR occurs during data communications if the cable becomes disconnected, if the parameters of the two units do not match, or if any other communications problem occurs. When this happens, press [AC] to clear the error and correct the problem before trying data communications again. In this case, any data received before the problem occurred is cleared from the receiving unit's memory.
- A MEMORY FULL operation occurs if the receiving unit memory becomes full during data communications. When this happens, press [AC] to clear the error and delete unneeded data from the receiving unit to make room for the new data, and then try again.

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Appendix

The appendix contains information on battery replacement, error messages, specifications, and other details.

Appendix A Power Supply
Appendix B To Reset the Calculator
Appendix C Function Reference
Appendix D Error Message Table
Appendix E Input Ranges
Appendix F Specifications

Appendix A Power Supply

This unit is powered by four AAA-size (LR03 (AM4) or UM-4) batteries. In addition, it uses a single CR2032 lithium battery as a back up power supply for the memory.

■When to Replace Batteries

Replace batteries when the display of the calculator becomes dim and difficult to read, even if you adjust the contrast (page 26) to make it darker.
If the following message appears on the display, immediately stop using the calculator and replace batteries. If you try to continue using the calculator, it will automatically switch power off, in order to protect memory contents.
You will not be able to switch power back on until you replace batteries.

```
**Low battery!**
```

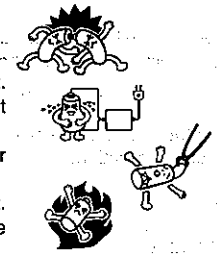
Be sure to replace batteries at least once every two years, no matter how much you use the calculator during that time.

Warning!
If you remove both the main power supply and the memory back up batteries at the same time, all memory contents will be erased. Be sure to read the following section before doing anything.

■Replacing Batteries

- Be sure that you have back up copies of all your memory contents before replacing batteries.
- Never remove the main power supply and the memory back up batteries at the same time. Doing so will erase the contents of the memory.
- Be sure that the calculator is switched off whenever you replace batteries. If the calculator is on, data stored in memory will be erased.
- Never switch the calculator on while batteries are not loaded or while a battery holder is not in place. Doing so will erase the contents of the memory.

Precautions:
Incorrectly using batteries can cause them to burst or leak, possibly damaging the interior of the unit. Note the following precautions:
- Be sure that the positive ⊕ and negative ⊖ poles of each battery are facing in the proper direction.



- Never mix batteries of different types.
- Never mix old batteries and new ones.
- Never leave dead batteries in the battery compartment.
- Remove the batteries if you do not plan to use the unit for long periods.
- Replace the batteries at least once every year, no matter how much the unit is used during that period.
- Never try to recharge the batteries supplied with the unit.
- Do not expose batteries to direct heat, let them become shorted, or try to take them apart.

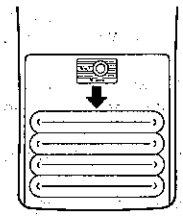
(Should a battery leak, clean out the battery compartment of the unit immediately, taking care to avoid letting the battery fluid come into direct contact with your skin.)

Keep batteries out of the reach of small children. If swallowed, consult with a physician immediately.)

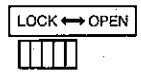
● To replace the main power supply batteries

① Switch the power of the calculator off.

② Slide the battery compartment cover on the back of the unit in the direction indicated by the arrow.

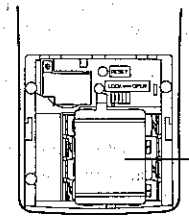


③ Slide up the switch on the battery holder to the OPEN side.

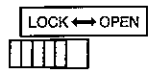


④ Remove the four old batteries.

⑤ Wipe off four new batteries with a soft, dry cloth. Load them into the calculator so that their positive ⊕ and negative ⊖ ends are facing properly. Be sure to replace all four batteries with new ones.

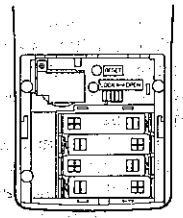


⑥ Replace the battery holder and fasten it in place. Slide the switch back down (LOCK side).



⑦Replace the battery compartment cover, sliding in the direction opposite that indicated by the arrow.

⑧Switch the power of the calculator on and check for proper operation.



Important

*Never remove the main power supply and the memory back up batteries from the unit at the same time.
*Be sure to switch the unit off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.
*Never switch power on main power supply batteries are removed from the unit or while the battery holder is not securely in place. Doing so will cause data in memory to be deleted.
*Be sure to replace all four batteries with new ones.

• To replace the memory back up battery

①Switch the power of the calculator off.

②Slide the battery compartment cover on the back of the unit in the direction indicated by the arrow.

③Remove screw Ⓐ from the battery holder.

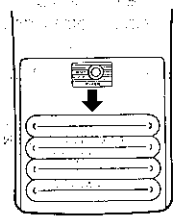
④Remove the old battery.

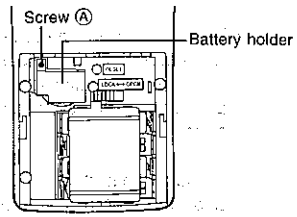
⑤Wipe off the surfaces of a new battery with a soft, dry cloth. Load it into the calculator so that its positive ⊕ side is facing up.

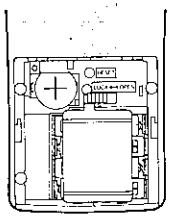
⑥Replace the battery holder and fasten it in place with screw Ⓐ.

⑦Replace the battery compartment cover, sliding in the direction opposite that indicated by the arrow.

⑧Switch the power of the calculator on and check for proper operation.







Important

*Before replacing the memory backup battery, switch on the unit and check to see if the "Low battery" message appears on the display. If it does, replace the main power supply batteries before replacing the back up power supply battery.
*Never remove the main power supply and the memory back up batteries from the unit at the same time.
*Be sure to switch the unit off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.
*Be sure to replace the back up power supply battery at least once a year, regardless of how much you use the unit during that time. Failure to do so will cause data in memory to be deleted.

■About the Auto Power Off Function

The calculator switches power off automatically if you do not perform any key operation for about 6 minutes. To restore power, press [AC/ON].

Appendix B To Reset the Calculator

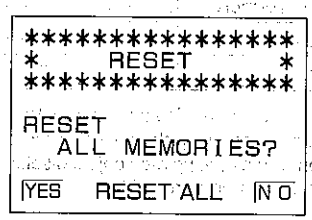
Warning!

The procedure described here clears all memory contents. Never perform this operation unless you want to totally clear the memory of the calculator.

Strong electrostatic charge can corrupt the operating system of the calculator, which interferes with correct operation. When this happens (or if you want to totally clear the memory for any other reason), you have to reset the calculator.

• To reset the calculator

①Switch the power of the calculator on.
②Press [MENU] to display the Main Menu.
③Use the cursor keys to select the **RESET** icon and then press [EXE] (or [log]).



④Press [F1](YES) to reset the calculator, or [F6](NO) to abort the reset operation.

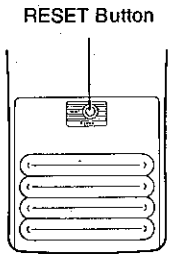
[F1](YES)

```
****************
*              *
*RESET         *
*              *
* ALL MEMORIES!*
*              *
*              *
****************
```

Resetting the calculator initializes the modes to the following settings.

Item	Initial Setting
Mode	COMP
Unit of Angular Measurement	Deg
Norm	Norm 1
BASE-N	Dec
Value Memories	Clear
Expanded Memory	Clear
Function Memory	Clear
Ans Memory	Clear
Graphic Display	Clear
Text Display	Clear
Equation Memory	Clear
Statistical Data Memory	Clear
Matrix Memory	Clear
Graphic Function Memory	Clear
Input Buffer	Clear
Program	Clear

*A RESET button is also located inside of the battery compartment, which you can open by removing the cover on the back of the unit. Pressing this button with a thin, pointed object displays the reset confirmation message shown on page 261.



Appendix C Function Reference

■Manual Calculations

Mode specification	COMP Mode (see page 18)	Four arithmetic and function calculations.
	BASE Mode (see page 18)	Binary, octal, decimal, hexadecimal conversions and calculations, logical operations.
	SD Mode (see page 18)	Standard deviation calculations (1-variable statistical).
	REG Mode (see page 18)	Regression calculations (paired variable statistical).
	MAT Mode (see page 18)	Matrix calculations
	EQUA Mode (see page 18)	Quadratic equations, linear equations with two or three unknowns.
Statistical graph	SD Mode (see page 78, 156)	For production of single variable statistical graphs. (Bar graphs, line graphs, normal distribution curves)
	REG Mode (see page 85, 159)	For production of paired variable statistical graphs. (Regression lines)
Functions	Type A functions	Function command input immediately after numeric value. [x^2, x^{-1}, $x!$, ° ' ", ENG symbols]
	Type B functions	Function command input immediately before numeric value. (sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, log, ln, e^x, 10^x, $\sqrt{}$, $\sqrt[3]{}$, etc.)
	Paired variable functions	Function command input between two numeric values. Numeric value enclosed in parentheses input immediately after function command. (A x^y B (A to the Bth power), B $\sqrt[x]{}$ A (A to the 1/Bth power), Pol (A, B), Rec (A, B)) *A and B are numeric values.*
	Immediately executed functions	Displayed value changed with each press of a key. [ENG, $\overleftarrow{\text{ENG}}$, $\overleftarrow{\text{° ' "}}$]

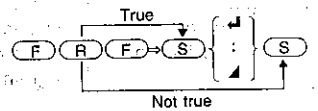
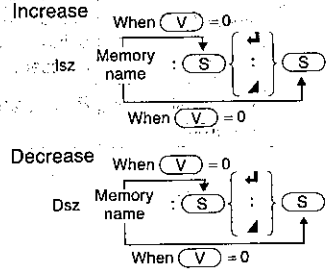
Binary, octal, decimal, hexadecimal calculations (see page 44, 46)	Setting number system	Decimal ..... [F1](Dec)[EXE] Hexadecimal ..... [F2](Hex)[EXE] Binary ..... [F3](Bin)[EXE] Octal ..... [F4](Oct)[EXE]
	Number system specification	Number system for the numeric value entered immediately after can be specified regardless of the currently set number system. To specify: Decimal ..... [F5](d~o)[F1](d) Hexadecimal ..... [F5](d~o)[F2](h) Binary ..... [F5](d~o)[F3](b) Octal ..... [F5](d~o)[F4](o)
	Logical operations	Input numeric values are converted to binary and each bit is tested. Result is converted back to number system used for input, and then displayed. Not ..... Reverse of each bit and ..... Logical product of each bit or ..... Logical sum of each bit xor ..... Exclusive logical sum of each bit xnor ..... Exclusive negative logical sum of each bit
Standard deviation calculations (see page 78)	Data clear	[SHIFT][CLR][F2](Scl)[EXE]
	Data input	Data [;frequency] [F1](DT) **Frequency can be omitted.*
	Data deletion	Data [;frequency] [F2](CL) **Frequency can be omitted.*
	Result display	Number of data (n) ..... [F5](Σ)[F3](n)[EXE] Sum (Σx) ..... [F5](Σ)[F2](Σx)[EXE] Sum of squares (Σx^2) .... [F5](Σ)[F1](Σx^2)[EXE] Mean ($\bar{x}$) ..... [F4](DEV)[F1]($\bar{x}$)[EXE] Population standard deviation ($x\sigma_n$) ..... [F4](DEV)[F2]($x\sigma_n$)[EXE] Sample standard deviation ($x\sigma_{n-1}$) ..... [F4](DEV)[F3]($x\sigma_{n-1}$)[EXE]
	Probability distribution calculations	P(t) ..... [F6](PQR)[F1](P() Q(t) ..... [F6](PQR)[F2](Q() R(t) ..... [F6](PQR)[F3](R() t(x) ..... [F6](PQR)[F4](t()
	Data storage	[F4](DEV)[F4](▽)[F1](Mod) [F4](DEV)[F4](▽)[F2](Med) [F4](DEV)[F4](▽)[F3](Max) [F4](DEV)[F4](▽)[F4](Min)

Regression calculations (see page 85)	Data clear	[SHIFT][CLR][F2](Scl)[EXE]
	Data input	x data, y data [;frequency] [F1](DT) **Frequency can be omitted.*
	Data deletion	x data, y data [;frequency] [F2](CL) **Frequency can be omitted.*
	Result display	Number of data (n) ..... [F6](Σ)[F3](n)[EXE] Sum of x (Σx) ..... [F6](Σ)[F2](Σx)[EXE] Sum of y (Σy) ..... [F6](Σ)[F5](Σy)[EXE] Sum of squares of x (Σx^2) ..... [F6](Σ)[F1](Σx^2)[EXE] Sum of squares of y (Σy^2) ..... [F6](Σ)[F4](Σy^2)[EXE] Sum of products of x and y (Σxy) ..... [F6](Σ)[F6](Σxy)[EXE] Mean of x ($\bar{x}$) ..... [F4](DEV)[F1]($\bar{x}$)[EXE] Mean of y ($\bar{y}$) ..... [F4](DEV)[F4]($\bar{y}$)[EXE] Population standard deviation of x ($x\sigma_n$) ..... [F4](DEV)[F2]($x\sigma_n$)[EXE] Population standard deviation of y ($y\sigma_n$) ..... [F4](DEV)[F5]($y\sigma_n$)[EXE] Sample standard deviation of x ($x\sigma_{n-1}$) ..... [F4](DEV)[F3]($x\sigma_{n-1}$)[EXE] Sample standard deviation of y ($y\sigma_{n-1}$) ..... [F4](DEV)[F6]($y\sigma_{n-1}$)[EXE] Constant term of regression formula (A) ..... [F6](REG)[F1](A)[EXE] Regression coefficient (B) ..... [F6](REG)[F2](B)[EXE] Correlation coefficient (r) ..... [F6](REG)[F3](r)[EXE] Estimated value of x ($\hat{x}$) ..... [F6](REG)y data [F4]($\hat{x}$)[EXE] Estimated value of y ($\hat{y}$) ..... [F6](REG)x data [F5]($\hat{y}$)[EXE]

Special functions	Ans	The latest result obtained in manual or program calculations is stored in memory. It is recalled by pressing [SHIFT][Ans]. **Mantissa of numeric value is 13 digits.*
	Replay	•After calculation results are obtained, the formula can be recalled by pressing either ◀ or ▶. •If an error is generated, pressing either ◀ or ▶ will cancel the error and the point where the error was generated will be indicated by a blinking cursor.
	Multistatement	Colons are used to join a series of statements or calculation formulas. If joined using "◢", the calculation result to that point is displayed.
	Memory	The number of memories can be expanded from the standard 28. Memories can be expanded in units of one up to 500 (for a total of 528). Eight steps are required for one memory. [SHIFT][Delete] number of memories [EXE].
Graph function	Range	Graph range settings Xmin ..... Minimum value of x Xmax ..... Maximum value of x Xscl ..... Scale of X-axis (space between points) Ymin ..... Minimum value of y Ymax ..... Maximum value of y Yscl ..... Scale of Y-axis (space between points) T, θ min .... Minimum value of T/θ T, θ max ... Maximum value of T/θ T, θ ptch ... Pitch of T/θ
	Trace	Moves pointer on graph. Current coordinate location is displayed.
	Plot	Marks pointer (blinking dot) at any coordinate on the graph display.
	Line	Connects with a straight line two points created with plot function.
	Box	Defines area for zoom in.
	Factor	Defines factor for zoom in/zoom out.
	Original	Returns graph to original dimensions after zoom operation.
	Scroll	Scrolls screen to view parts of graphs that are off the display.

■Program Calculations

Program input	Calculation mode	Mode that conforms with program specified by: [SHIFT][SETUP][F1](CMP) ([F2](BAS), [F3](SD), [F4](REG), [F5](MAT))
	Program area specification	Cursor is moved to the desired program area name (P0 through P9, PA through PZ, Pr, Pθ) using ▲ and ▼, and [EXE] is pressed.
Program execution	Program area specification	Execution starts with [SHIFT][PRGM][F3](Prg) program area name [EXE]. Program area name: P0 through P9, PA through PZ, Pr, Pθ
Program editing	Program area specification	Cursor is moved to the desired program area name (P0 through P9, PA through PZ, Pr, Pθ) using ▲ or ▼, and [EXE] is pressed.
	Editing	Cursor is moved to position to be edited using ◀, ▶, ▲ or ▼. •Press correct key for corrections. •Press [DEL] for deletions. •Press [SHIFT][INS] to specify insert mode for insertion.
Program delete	Deletes specific program	Cursor is moved to the desired program area name (P0 through P9, PA through PZ, Pr, Pθ) using ▲ and ▼, and [F2](DEL)[F1](YES) is pressed.
	Clears all programs	Press [F3](DL·A)[F1](YES)

Program commands	Unconditional jump	Program execution jumps to the Lbl n which corresponds to Goto n. *n = 0 through 9
	Conditional jumps	If conditional expression is true, the statement after "⇒" is executed. If not true, execution jumps to the statement following next "↵", ":" or "◢".  (F) : Formula (R) : Relational operator (S) : Statement *The relational operator is: =, ≠, >, <, ≥, ≤.
	Count jumps	The value in a memory is increased or decreased. If the value does not equal 0, the next statement is executed. If it is 0, a jump is performed to the statement following the next "↵", ":" or "◢".  (S) : Statement (V) : Value in memory
	Subroutines	Program execution jumps from main routine to subroutine indicated by Prog n (n = 0 through 9, A through Z, r, θ). After execution of the subroutine, execution returns to the point following Prog n in the original program area.

Appendix D Error Message Table

Message	Meaning	Countermeasure
Syn ERROR	①Calculation formula contains an error. ②Formula in a program contains an error.	①Use ◀ or ▶ to display the point where the error was generated and correct it. ②Use ◀ or ▶ to display the point where the error was generated and then correct the program.
Ma ERROR	①Calculation result exceeds calculation range. ②Calculation is performed outside the input range of a function. ③Illogical operation (division by zero, etc.) ④Poor precision in differential calculation results. ⑤Poor precision in integration calculation results. ⑥Cannot find results of equation calculations.	①②③ Check the input numeric value and correct it. When using memories, check that the numeric values stored in memories are correct. ④Try using a smaller value for Δx (x increment/decrement). ⑤Try using a larger value for n (number of partitions). ⑥Check the coefficients of the equation.
Go ERROR	①No corresponding Lbl n for Goto n. ②No program stored in program area P n which corresponds to Prog n.	①Correctly input a Lbl n to correspond to the Goto n, or delete the Goto n if not required. ②Store a program in program area P n to correspond to Prog n, or delete the Prog n if not required.
Ne ERROR	•Nesting of subroutines by Prog n exceeds 10 levels.	•Ensure that Prog n is not used to return from subroutines to main routine. If used, delete any unnecessary Prog n. •Trace the subroutine jump destinations and ensure that no jumps are made back to the original program area. Ensure that returns are made correctly.
Stk ERROR	•Execution of calculations that exceed the capacity of the stack for numeric values or stack for calculations.	•Simplify the formulas to keep stacks within 10 levels for the numeric values and 26 levels for the calculations. •Divide the formula into two or more parts.

Mem ERROR	①Specified expanded value memory does not exist. ②Not enough memory to expand value memories specified number. ③Not enough memory to input a function into function memory. ④Not enough memory to create a matrix using the specified dimension. ⑤Not enough memory to hold matrix calculation result. ⑥Not enough memory to store statistical data. ⑦Not enough memory to input coefficient for equation. ⑧Not enough memory to hold equation calculation result. ⑨Not enough memory to hold function input in the Graph Mode for graph drawing.	①Use [SHIFT] [DelIn] to correctly expand the number of value memories. ②③④⑤⑥⑦⑧⑨ •Keep the number of value memories you use for the operation within the number of value memories currently available. •Simplify the data you are trying to store to keep it within the available memory capacity. •Delete no longer needed data to make room for the new data.
Arg ERROR	Incorrect argument specification for a command that requires an argument.	Correct the argument. •Sci n, Fix n: n = integer from 0 through 9. •Lbl n, Goto n: n = integer from 0 through 9. •Prog n: n = 0 through 9, A through Z, r, θ. •Defm n: n = integer from 0 up to the number of remaining bytes.
Dim ERROR	•Illegal dimension used during matrix calculations.	•Check matrix dimension.
TRANSMIT ERROR!	Problem with cable connection or parameter setting during data communications.	•Check cable connection. •Check to see that the parameters of the sending unit and receiving unit are identical.
RECEIVE ERROR!	Problem with cable connection or parameter setting during data communications.	•Check cable connection. •Check to see that the parameters of the sending unit and receiving unit are identical.
MEMORY FULL!	Memory of receiving unit became full during program data communications.	•Delete some data stored in the receiving unit and try again.

Appendix E Input Ranges

Function	Input range	Internal digits	Accuracy	Notes
$\sin x$ $\cos x$ $\tan x$	(DEG) $\lvert x\rvert < 9\times10^{9}$° (RAD) $\lvert x\rvert < 5\times10^{7}\pi$rad (GRA) $\lvert x\rvert < 1\times10^{10}$grad	13 digits	As a rule, accuracy is ±1 at the 10th digit.	Howver, for $\tan x$: $\lvert x\rvert \neq 90(2n+1)$:DEG $\lvert x\rvert \neq \pi/2(2n+1)$:RAD $\lvert x\rvert \neq 100(2n+1)$:GRA
$\sin^{-1}x$ $\cos^{-1}x$	$\lvert x\rvert \leqq 1$	〃	〃	
$\tan^{-1}x$	$\lvert x\rvert < 1\times10^{100}$			
$\sinh x$ $\cosh x$	$\lvert x\rvert \leqq 230.2585092$	〃	〃	Note: For sinh and tanh, when $x=0$, errors are cumulative and accuracy is affected at a certain point.
$\tanh x$	$\lvert x\rvert < 1\times10^{100}$			
$\sinh^{-1}x$	$\lvert x\rvert < 5\times10^{99}$	〃	〃	
$\cosh^{-1}x$	$1 \leqq x < 5\times10^{99}$			
$\tanh^{-1}x$	$\lvert x\rvert < 1$			
$\log x$ $\ln x$	$1\times10^{-99} \leqq x < 1\times10^{100}$	〃	〃	
10^{x}	$-1\times10^{100} < x < 100$	〃	〃	
e^{x}	$-1\times10^{100} < x \leqq 230.2585092$			
$\sqrt{x}$	$0 \leqq x < 1\times10^{100}$	〃	〃	
x^{2}	$\lvert x\rvert < 10^{50}$			
$1/x$	$\lvert x\rvert < 1\times10^{100}$, $x \neq 0$	〃	〃	
$\sqrt[3]{x}$	$\lvert x\rvert < 1\times10^{100}$			
$x!$	$0 \leqq x \leqq 69$ (x is an integer)	〃	〃	
nPr nCr	Result $< 1\times10^{100}$ n, r (n and r are integers) $0 \leqq r \leqq n$, $n < 1\times10^{10}$	〃	〃	
Pol (x, y)	$\sqrt{x^2+y^2} < 1\times10^{100}$	〃	〃	

Function	Input range	Internal digits	Accuracy	Notes
Rec (r, θ)	$0 \leqq r < 1 \times 10^{100}$ (DEG) $\lvert\theta\rvert < 9 \times 10^{9}$° (RAD) $\lvert\theta\rvert < 5 \times 10^{7}$ πrad (GRA) $\lvert\theta\rvert < 1 \times 10^{10}$grad	13 digits	As a rule, accuracy is ± 1 at the 10th digit.	However, for tanθ: $\lvert\theta\rvert \neq 90(2n+1)$:DEG $\lvert\theta\rvert \neq \pi/2(2n+1)$:RAD $\lvert\theta\rvert \neq 100(2n+1)$:GRA
°′″	$\lvert a\rvert$, b, $c < 1 \times 10^{100}$ $0 \leqq$ b, c	〃	〃	
← °′″	$\lvert x\rvert < 1 \times 10^{100}$ Hexadecimal display: $\lvert x\rvert \leqq 1 \times 10^{7}$			
^ (x^y)	$x > 0$: $-1 \times 10^{100} < y \log x < 100$ $x = 0$: $y > 0$ $x < 0$: $y = n, \frac{1}{2n+1}$ (n is an integer) However; $-1 \times 10^{100} < \frac{1}{y} \log \lvert x\rvert < 100$	〃	〃	
$\sqrt[x]{y}$	$y > 0$: $x \neq 0$ $-1 \times 10^{100} < \frac{1}{x} \log y < 100$ $y = 0$: $x > 0$ $y < 0$: $x = 2n+1, \frac{1}{n}$ ($n \neq 0$, n is an integer) However; $-1 \times 10^{100} < \frac{1}{x} \log \lvert y\rvert < 100$	〃	〃	
$a^b/_c$	•Results Total of integer, numerator and denominator must be within 10 digits (includes division marks). •Input Result displayed as a fraction for integer when integer, numerator and denominator are less than 1×10^{10}.	〃	〃	
SD (REG)	$\lvert x\rvert < 1 \times 10^{50}$ $\lvert y\rvert < 1 \times 10^{50}$ $\lvert n\rvert < 1 \times 10^{100}$ $x\sigma n$, $y\sigma n$, $\bar{x}$, $\bar{y}$, A, B, r: $n \neq 0$ $x\sigma n-1$, $y\sigma n-1$: $n \neq 0, 1$	〃	〃	

Function	Input range
BASE-N	Values after variable within following range: DEC: $-2147483648 \leqq x \leqq 2147483647$ BIN: $1000000000000000 \leqq x$ $\leqq 1111111111111111$ (negative) $0 \leqq x \leqq 0111111111111111$ (0, positive) OCT: $20000000000 \leqq x \leqq 37777777777$ (negative) $0 \leqq x \leqq 17777777777$ (0, positive) HEX: $80000000 \leqq x \leqq$ FFFFFFFF (negative) $0 \leqq x \leqq$ 7FFFFFFF (0, positive)

*Errors may be cumulative with internal continuous calculations such as x^y, $\sqrt[x]{y}$, $x!$, $\sqrt[3]{}$ sometimes affecting accuracy.

Appendix F Specifications

Model: fx-7700GE

Calculations

Basic calculation functions:
Negative numbers, exponents, parenthetical addition/subtraction/multiplication/division (with priority sequence judgement function — true algebraic logic).

Built-in scientific functions:
Trigonometric/inverse trigonometric functions (units of angular measurement: degrees, radians, grads); hyperbolic/inverse hyperbolic functions; logarithmic/exponential functions; reciprocals; factorials; square roots; cube roots; powers; roots; squares; decimal-sexagesimal conversions; permutations/combinations; π; random numbers; internal rounding; fraction functions; engineering and engineering symbol (11 types) calculations; negative signing; exponential notation input; parenthetical calculations; coordinate transformations; number of decimal place and significant digit specification

Matrix operations:
Addition, subtraction, multiplication; scalar products; matrix transposition; determinants; inversion; squaring; row operations; dimension specification capabilities

Differentials: Extraction of derivative using differential from center point.

Integrations: Using Simpson's rule.

Equation calculation function:
Linear equation with two or three unknowns; quadratic equations; recall of solutions and coefficients

Statistics:
Standard deviation: number of data; mean; standard deviation (two types); sum; sum of squares; statistical calculation of mode, median, maximum value, minimum value; normal distribution calculation

Regression:
number of data; mean of x; mean of y; standard deviation of x (two types); standard deviation of y (two types); sum of x; sum of y; sum of squares of x; sum of squares of y; sum of square of x and y; fixed term; regression coefficient; correlation coefficient; estimated value of x; estimated value of y

Value memories: 28 standard, expandable up to 528

Calculation range:
1×10^{-99} to $9.999999999 \times 10^{99}$ and 0. Internal operation uses 13-digit mantissa.

Exponential display: Norm 1: $10^{-2} > |x|, |x| \geq 10^{10}$
Norm 2: $10^{-9} > |x|, |x| \geq 10^{10}$

Rounding:
Performed according to the specified number of significant digits and number of specified decimal places.

Graph functions

Built-in function graphs (rectangular and polar coordinates):
(40 types) sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, lo
ln, 10^x, e^x, x^2, $\sqrt{\ }$, $\sqrt[3]{\ }$, x^{-1}

Graph types: Rectangular coordinate graphs: $y=f(x)$
Polar coordinate graphs: $r=f(\theta)$
Parametric graphs: $(x, y)=(f(T), g(T))$
Inequality graphs: $(y>f(x), y<f(x), y\geq f(x), y\leq f(x))$
Integral graphs
Probability distribution graphs
Single-variable statistical graphs (bar histograms, line graphs, norm
distribution curves)
Paired-variable statistical graphs (regression line, logarithmic regressi
curve; exponential regression curve; power regression curve)

Graph memory: Graph function storage, editing, selection, drawing

Graph functions:
Range specification; overwrite, trace, plot, line, scroll, zoom, box and factor zoom (×
$\times 1/\square$, Original) capabilities

Programming

Program commands: Unconditional jumps: Goto, Lbl
Conditional jumps: ⇒, ◢, logical operators (=, ≠, >, <, ≥, ≤
Jumps with count: Isz, Dsz
Subroutine calls: Prog, up to 10 levels of nesting

Number of stored programs: 38 maximum (P0 to P9; PA to PZ; Pr, Pθ)

Check functions: Program checking, debugging

Program area: 4,000 bytes maximum

Program communications

Communication functions:
Communication of all memory contents: programs, function memories, matrix memories
single- or paired-variable statistical data, value memory and expanded memory content
graph range parameters, factoring ratios, graph functions, formula coefficients

Communication method: Start-stop (asynchronous), half-duplex.

Transmission speed: 1200, 2400, 4800, 9600 (bps)

Parity: Even, odd, none

Bit length: 8 bits

Stop bit:
Send: 2 bits
Receive: 1 bit

General

Display system:
16-character × 8-line liquid crystal display; 10-digit mantissa and 2-digit exponent for calculations; displays binary, octal, hexadecimal, sexagesimal values, fraction

Power supply: Main: Four AAA-size batteries (LR03 (AM4) or R03 (UM-4))
Memory protection: One CR2032 lithium battery

Power consumption: 0.1W

Battery life Main: Approximately 350 hours (continuous display of 0) on battery type LR03 (AM4)
Approximately 200 hours (continuous display of 0) on battery type R03 (UM-4)
Approximately 2 years (power switch off) on LR03 (AM4)/R03 (UM-4)
Memory protection: Approximately 1 year

Auto power off:
Power is automatically switched off approximately six minutes after last operation.

Ambient temperature range: 0°C~40°C (32°F~104°F)

Dimensions: 20mmH × 85mmW × 172.5mmD (¾"H×3⅜"W×6¾"D)

Weight: 218.5g (7.7oz) including batteries

Accessories: Hard Case

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Key	Primary Function	combined with SHIFT	combined with AL
Trace F1	Turns trace function on/off. Selects 1st function menu item.		
Zoom F2	Turns zoom function on. Selects 2nd function menu item.		
Plot F3	Turns plot function on. Selects 3rd function menu item.		
Line F4	Turns line function on. Selects 4th function menu item.		
Cls F5	Clears the graph screen. Selects 5th function menu item.		
Coord F6	Displays graph coordinates. Selects 6th function menu item.		
SHIFT	Activates shift functions of other keys and function menus.		
A-LOCK ALPHA	Allows entry of alphanumeric characters shown in red.	Locks/Unlocks entry of alphanumeric characters.	
QUIT EXIT	Backsteps to the previous menu.	Returns directly to the initial screen of the mode.	
SET UP MENU	Returns to the Main Menu .	Shows the set up display.	
G-$\int dx$: G↔T	Switches display between graph & text screens.	Provides graphic integral solution.	Enters colon.
d/dx r Graph	Activates graph function.	Provides numerical differential solution.	Enters characte r.
θ Range	Displays range parameter input screen.		Enters characte θ.
CAPA : M Disp	Displays current mode settings. (press & hold) Transfers screen shot to personal computer.	Press and hold to display remaining memory capacity.	Enters semicol
▲	Moves cursor upward. Scrolls screen.	Switches to next function in trace mode.	
▼	Moves cursor downward. Scrolls screen.	Switches to next function in trace mode.	
◀	Moves cursor to left. Scrolls screen. Press after EXE to display calculation from end.		

Key Index

Key	Primary Function	combined with SHIFT	combined with ALPHA
▶	Moves cursor to right. Scrolls screen. Press after EXE to display calculation from beginning.		
∫dx A (X,θ,T)	Allows input of variables X,θ, and T.	Provides numerical integral solution.	Enters letter A.
10^x B (log)	Press before entering value to calculate common logarithm.	Press before entering exponent value of 10.	Enters letter B.
e^x C (ln)	Press before entering value to calculate natural logarithm.	Press before entering exponent value of e.	Enters letter C.
sin⁻¹ D (sin)	Press before entering value to calculate sine.	Press before entering value to calculate inverse sine.	Enters letter D.
cos⁻¹ E (cos)	Press before entering value to calculate cosine.	Press before entering value to calculate inverse cosine.	Enters letter E.
tan⁻¹ F (tan)	Press before entering value to calculate tangent.	Press before entering value to calculate inverse tangent.	Enters letter F.
d/c G (a b/c)	Press between entering fraction values. Converts fraction to decimal.	Displays improper fraction.	Enters letter G.
√ H (x²)	Press after entering value to calculate square.	Press before entering value to calculate square root.	Enters letter H.
∛ I (( )	Enter open parenthesis in formula.	Press before entering value to calculate cube root.	Enters letter I.
x⁻¹ J ( ))	Enter close parenthesis in formula.	Press after entering value to calculate reciprocol.	Enters letter J.
, K (→)	Assigns value to a value memory name.	Enters comma.	Enters letter K.
ˣ√ L (^)	Press between two values to make second value exponent of first.	Press between entering values for x & y to show xth root of y.	Enters letter L.
PRGM M (7)	Enters number 7.	Displays program command menu.	Enters letter M.
N (8)	Enters number 8.		Enters letter N.
O (9)	Enters number 9.		Enters letter O.
INS (DEL)	Deletes character at current cursor location.	Allows insertion of characters at cursor location.	

Key	Primary Function	combined with SHIFT	combined with ALPH
OFF (AC/ON)	Turns power on. Clears the display.	Turns power off.	
P (4)	Enters number 4.		Enters letter P.
MATH Q (5)	Enters number 5.	Display built in function menu.	Enters letter Q.
VAR R (6)	Enters number 6.	Displays variable data menu.	Enters letter R.
← S (×)	Multiplication function.		Enters letter S.
T (÷)	Division function.		Enters letter T.
DRG U (1)	Enters number 1.	Sets/converts unit of angular measurement.	Enters letter U.
DISP V (2)	Enters number 2.	Displays menu of display format choices.	Enters letter V.
CLR W (3)	Enters number 3.	Displays memory clear menu.	Enters letter W.
X (+)	Addition function. Specifies positive value.		Enters letter X.
Y (−)	Subtraction function. Specifies negative value.		Enters letter Y.
F MEM Z (0)	Enters number 0.	Displays function memory menu.	Enters letter Z.
Defm [(.)	Enters decimal point.	Shows memory status.	Enters open bracket.
π] (EXP)	Allows entry of exponent.	Inputs value of pi. Enters pi symbol.	Enters close bracket.
Ans SPACE (−)	Enter before value to specify as negative.	Recalls most recent calculation result.	Enters a blank space.
↵ (EXE)	Displays result of calculation.	Inputs a new line.	